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PROGRESS IN THE MOTION PICTURE INDUSTRY

April 1927 Report of the Progress Committee

Introduction.

THOMAS A. EDISON, when quizzed on his eightieth birthday as to the future of motion pictures, replied, "onward and upward." He struck the key note of the industry. One need not stretch the imagination far to paint a picture of the future in which sound synchronization, television, and stereoscopic principles are combined to give super-entertainment and service. Some day we may sit at home and see a great play, enacted in a magnificent theater in a distant city, projected in relief, and hear the words of the actors and the musical accompaniment. Instead of "tuning in" on our favorite musical entertainment, we may turn to our favorite play. Just what the future holds in store is a matter of conjecture, but it is certain that we are traveling "onward and upward."

Perhaps the most recent evidence of progress which will affect our industry is the feat of sending action pictures by wire from Washington to New York.¹ Secretary Hoover's face was transmitted and expressions were clearly shown as he talked over the telephone. And a studio entertainment was transmitted by radio from Whippany, New Jersey, to New York; scenes were thrown on the screen with, it is reported, all the realism of a motion picture. The voices of the actors were also carried by the radio.

Fifty years ago wet plates and albuminized paper were the principle photographic materials,² but after the introduction of the gelatin process the photographic industry expanded to the point where 40,000 persons are employed in connection with the manufacture of sensitized materials and cameras. Though we were retarded at first by the complexity of the problem, much progress has been made in recent years, including improvements in sensitivity of emulsions and applications of photography, aerial photography, photolithography, color sensitivity and motion pictures.

There has been some contention recently as to just who "invented" motion pictures.³ The developments of Jenkins, Friese-Greene, Lumière, and Skladanowsky, have been debated with reference to their priority in the invention of the motion picture apparatus. In one history of cinematography recently written, it is claimed that L. Lumière originated motion picture projection⁴ and that Edison

perfected a means for viewing, photographically, motion synthesis which could be used by one person only at one time. (Lumière's first motion picture films made in 1894-5, and which are in possession of W. Day, are still flexible and capable of projection.⁵) Another writer states that the motion picture business started in a small room on Broadway in 1895. Taking pictures out of the "peepboxes" and putting them on the screen was the task of the pioneers and is outlined in an article published early this year⁶ dealing with the evolution of the motion picture business.

In the thousandth issue of *Kinematographic Weekly Supplement*, twenty years of film progress is summarized.⁷ The early lantern inventions of Kircher, Brewster, down to those of Friese-Greene, Evans and Edison are reviewed. A 14-reel historical film entitled "Thirty Years of Motion Pictures" was one of the features of the Third Annual Films Convention of the National Board of Review.⁸ "The Motion Picture, its Broadening Influence and Uses" was the key note of the conference.⁹ The social influences of the motion picture, its psychological influence, and its influence on the home and on the family were treated.

The economic and social aspects of the motion picture have been studied by the American Academy of Political and Social Science.¹⁰ Among the many subjects treated are financing, production, art, music, lighting and application of the motion picture to education, business, science and entertainment.

Many college men are taking up motion pictures as a career,¹¹ and actors are being sought from the colleges and universities.¹² Camera men were to tour universities throughout the country during April to make screen tests of undergraduates who appear as likely material for pictures. Every element that goes to the making of an actor of the highest type will be considered in the selection of the candidates. Facial features, physique, and intellect will undergo a thorough examination.

Respectfully submitted,

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Amateur Cinematography.

Amateur motion pictures continue to take a prominent position in the industry. While their worth has been established in the fields of business and pleasure, new uses are constantly being discovered. Among the most recent applications is their use to correct the form of athletes.¹³

Much has been written on the precautions to be taken with amateur apparatus and many suggestions have been given. Suitable arrangement of the room during projection and the proper care of the projector during its use have been discussed,¹⁴ as has the proper length of shots for average scenes taken with 16 mm cameras.¹⁵ A table was included¹⁵ showing the relation between crank turns, picture frames and footages for 16 and 35 mm film; the 10-second scene is advocated.

A new film library has been opened making possible the purchase of professional subjects on 16 mm film in short lengths at a nominal price;¹⁶ the subjects are reductions made from standard 35 mm professional films.

While the 16 mm size film is undoubtedly cheaper, great economies in the use of 35 mm film may be obtained, it is claimed, by using short pieces and end runs.¹⁷ Printing by the reversal process cannot be carried out, but the negative may be developed by the amateur and sent to a laboratory for printing.

Cameras.

One of the innovations at the Motion Picture Trade Exposition held March 7th to 12th, 1927, at the Ambassador Auditorium, was a vest pocket moving picture camera that, it is asserted, will faithfully photograph any scene which can be reported on regulation sized films.¹⁸ The camera weighs 14 ounces and is only 4 inches in length. Its magazine holds 20 feet of extra thin film stock of standard size.

A new speed motion picture camera has been designed and demonstrated which is capable of taking 2,600 photographs a second, more than 150 times as many as the ordinary motion picture camera.¹⁹ It is used to photograph electric spark discharges and for other experimental purposes.

The United States Army has developed a new aeroplane motion picture camera which takes a continuous series of pictures, records the time they are taken, the angle of the camera to the ground, the altitude, the number of exposures, the focal length of the lens, the day,

month, year and other particulars.²⁰ The camera does not require an operator and hence may be placed in the fastest single pursuit planes. The pilot merely starts the camera when he is over an area which he wishes to record and it takes the pictures and all the necessary data; an area of 180 square miles at an altitude of 15,000 feet can be mapped out allowing for 50 per cent overlap on the films.

Colored Motion Pictures.

While there continues to be no outstanding developments in the application of color cinematography, there is considerable patent activity in this field.

A new process of photography and ciné-photography in color has been devised²¹ in which an ordinary contact positive is printed from a single negative exposed through a grating with rulings parallel to tricolored filter bands in the objective. The positive is viewed directly through a sheet of ground glass, or by projection, being illuminated by a system of band filters and a grating similar to that in the camera. In cinephotography the grating is printed photographically on one side of the film before the panchromatic positive emulsion is coated on the other side.

Another motion picture color process has been developed which is said to have a combination of additive and subtractive features.²² Two images are taken, one recording red, yellow, and blue-violet, and the other orange, yellow, green, and blue. The corresponding positive images are colored yellow and are projected alternately through screens of violet and blue-green.

In projecting colored pictures, instead of using color filters which absorb part of the light, a series of prisms have been arranged in echelon, dispersing the light into its several color components, thus utilizing practically all of the light.²³

A patent has been granted on a process of producing motion picture film having identical emulsion quality. Two films which were originally cut from adjacent areas of a wide film band are exposed back to back,²⁴ and complementary pictures are printed on the registering areas; these are then developed by a relief method.

A motion picture film for use in the Keller-Dorian color process has been developed in which the bases of the lenticular elements are hexagonal and fit closely together.²⁵ The film used in taking is thicker than normal and the number of elements to the millimeter is less than 26; in projecting the number is greater than 23, the film is of normal

thickness and the emulsion is of very fine grain. A supplemental collimating lens, such that the pupil of emergence of the main objective, as viewed from the film, is situated at infinity, or at least a great distance in front of the lens, has been designed for use with the Keller-Dorian process;²⁶ and a method has been devised for making cylinders which impress reticulations into film to be used in this process.²⁷

Educational.

Much interest and activity are being displayed in the educational application of motion pictures. The worth of motion pictures in the schools and for other educational purposes is not yet generally established but many experiments have been and are being made from which conclusive evidence may be drawn. Perhaps the largest and most important of these is now being launched in many public schools.²⁸ Actual work is being done upon a series of fifty motion picture films especially designed for use in the class room. These are intended for fourth and higher grades in selected schools and will be shown within a two-year period assigned for the experiment. The films are laid out with a definite idea of following certain prescribed teachings. Each picture is being assembled by scientists and pedagogues with the realization that to be instructive the picture must also be interesting. If expectations are realized the films may be generally adopted for class room work.

Visual education by motion pictures and lantern slides has been tried out in the Potter's School of Pawtucket, Rhode Island.²⁹ There it is concluded that this method of teaching saves time, clarifies and clinches half-formed text-book impressions, and vitalizes dull subjects.

The motion picture program for a high school has been studied with reference to the types of pictures desired by each department of the school and methods of avoiding conflicts and repetition in classes.³⁰ A survey has been made of the relative status of fourteen different visual aids used in intermediate schools in various cities throughout the United States.³¹ Films are considered very effective whenever motion is to be shown, but it is said that they have certain weaknesses. A nationally known educator has conducted experimental tests upon films made for class room use, and reported his findings.³²

The educational application of motion pictures has also been tried out in England. It is asserted, in a report from the County High

School for Boys at Altrincham,³³ that no modern school without the cinema is properly equipped for the business of teaching. A discussion of the supply of films, the cost, and of the tests and results obtained, is given in the report.

Russia also seems to be using the motion picture for this purpose as evidenced by a recent order from the Optical Trust of Leningrad, Russia, calling for 2,000 projection machines³⁴ which are to be used in public schools for visual education.

It is said that teaching by talking and motion pictures should not be attempted at the same time.³⁵ The teacher should first talk, next project, and then summarize both the talk and the picture. The films should be correct to scale, artistic, worth while, true to life, of immediate appeal, should promote favorable emotional reactions and should provide stimulation to correct responses.³⁶

While most of the research work and experimenting is being done in connection with the lower grades, some colleges and institutions of higher learning recognize the possibilities of motion pictures. The Bellevue Hospital Medical College is now using them almost entirely in place of the amphitheater as a means of demonstrating operations to post graduate students.³⁷ The films are also being used to show the progress and cure of a disease and to bring microscopic studies close to the students.

Paralleling the activity in using motion pictures as an accessory to teaching is that of educating people in the art and science of motion picture photography. Several leading colleges and universities are either planning or have established courses in this subject. Lectures on motion picture topics will be given in the course in Business Policy at Harvard University.³⁸ Among leaders in the motion picture industry who are scheduled to talk are Cecil De Mille and Milton Sills. Plans are also being discussed for courses in Motion Picture Photography, Motion Picture Architecture, Business Administration and Scenario Writing which may be offered at Columbia University.³⁹

The army signal school at Post Monmouth, New Jersey, is to give a course in motion picture photography⁴⁰ which will train students in the making of historical and news pictures, thus better enabling the army to preserve pictorial records of its present and future activities.

Some foreign activity has also been evidenced in this field. A school has been established in Paris⁴¹ to teach photography and cinematography to technicians.

Films and Emulsions.

The most prominent progressive step in connection with films and emulsions is the increasing use of panchromatic motion picture film. It is said that more panchromatic negative film is now used than regular film.⁴² Until recently panchromatic materials were used only for the three-color process, but recent improvements in keeping quality, speed, and ease of handling with the aid of desensitizers, have made panchromatic materials desirable for motion picture, portraiture, and landscape photography. Its application to motion picture filming has made unnecessary the use of any other than ordinary "make-up," and permits lighting of studio sets in a manner similar to real life.⁴³

Lighting problems of desert scenes in filming "The Winning of Barbara Worth" were said to be greatly simplified by the use of panchromatic film.⁴⁴

To give a complete understanding of the principles involved in obtaining any desired reproduction of tone values by the photographic process, a thorough discussion of many factors, including the nature of light and radiation, the sensitivity of the eye and of the photographic materials to radiations of different wave lengths, the quality of radiation emitted by various light sources used for illuminating the set, and the reflection characteristics of objects, are covered in a series of articles being written on the subject "Panchromatic Motion Picture Film Negatives."⁴⁵

Paralleling the adoption of panchromatic emulsions is the activity toward increasing the sensitivity of all emulsions. Considerable work is evidenced at the present time in the direction of finding baths for treating negative film before exposure to increase its speed to an abnormal amount.⁴⁶

The sensitiveness of a silver emulsion is extended by including salts that are soluble in water,⁴⁷ the anions of which contain at least 3 atoms of an element of the sulphur group, and the sensitivity of silver salt emulsions has been increased⁴⁸ by the addition of thiazol compounds.

A new method of improving the light sensitiveness of photographic material which involves a colorless organic sensitizing material preferably derived from animal tissue in concentrated form, has been patented;⁴⁹ and a patent has been issued on a gelatino-silver-halide emulsion,⁵⁰ made by including a sensitizing material extracted from seed tissue.

A photographic emulsion has been produced, based on the use of salts of mercury, which functions as a developing out emulsion.⁵¹ Its light sensitiveness is increased by the addition of an independent thiocarbamide.

Autochrome plates may be hypersensitized⁵² by bathing with a solution of panchrome containing a minimum quantity of ammoniacal silver nitrate. Other sensitizing dyes may be substituted for panchrome. Fast non-color sensitive materials can be made orthochromatic by the use of the same dye.

Further study has been made of the reciprocal relation between time and intensity in photographic exposure.⁵³ It has been found that the maximum density obtainable with complete development depends upon the intensity used in making the exposure. Thus for silver halide grains there is an intensity-threshold below which the films cannot be developed no matter how long the exposure time is prolonged. Conversely, if the exposure intensity be sufficiently high all of the silver halide present in the emulsion can be developed. The causes of photographic sensitivity have also been explained.⁵⁴

While the problem of increasing the sensitivity of emulsions seems to be receiving most attention, other discoveries or innovations are being made, all of which tend to improve the final product. An acid amidol developer has been devised⁵⁵ which contains chrome alum; it prevents fog and makes possible the development of good negatives from bad over exposures.

A method representing a great advance in the measurement of the iodide content of photographic emulsions has been developed⁵⁶ and will be used by all large manufacturers to control the quality of their emulsions. It is a potentiometric method in which silver halide is dissolved in an excess of potassium cyanide, granulated zinc added and the solution boiled to reduce the silver halide to metallic silver. Acetic acid is added in excess and the solution is again boiled to remove all the cyanide. Ammonium nitrate is put in and the solution is then titrated with a silver nitrate solution and the end points are determined electrometrically. As little as 1 per cent silver iodide can be estimated with considerably accuracy in mixtures of silver halides by this method.

Direct positives have been made by the use of copper chloride,⁵⁷ a reversed positive being first produced on bromide paper by bleaching the strongly developed negative image with copper chloride. The

resulting silver chloride is then dissolved in ammonia after being washed, and the remaining silver bromide is developed in strong light to a positive image.

A series of experiments have been performed in study of the relation between the absorption of the various sensitizing dye-stuffs and the reversing of the red and infra-red rays.⁵⁸ It was found that dye stuffs which have a strong absorption band in the region of wavelengths longer than 550μ are effective in obtaining the reversed impressions.

A microcolorimetric method of silver analysis,⁵⁹ which involves precipitation of silver as colloidal silver-sulfide, permitting silver on an area of one square centimeter of density 0.10 to be determined to a few per cent, has been worked out. Several methods of recovering silver from fixing baths have been analyzed⁶⁰ with respect to the properties of the de-silvered hypo and possible financial returns.

The making of good duplicate negatives calls for great skill and makes stringent demands upon the materials available.⁶¹ An exposition of the requirements and of the process involved was given in a paper presented before the last meeting of the Society. It is necessary to choose an emulsion⁶² having considerable latitude and it should be developable to a low gamma.

A motion picture film has been made having a plurality of small protuberances along the film edge which,⁶³ it is claimed, increase the durability and lessen abrasion marks. The optics of production of rain effect from scratches and scars on the support side of positive film have been explained⁶⁴ and various methods of diminishing this effect and prolonging the useful life of old films described.

A new film cement consisting of collodion, acetic ether, alcohol, amyl acetate, ether and acetone has been patented.⁶⁵

A film is said to have been perfected by a British inventor which cannot burn,⁶⁶ and which supposedly may be produced on a commercial basis.

General.

The experimental work of motion picture photography has long been an expensive item in connection with production costs. There has been much duplication of effort by cinematographers in various studios. With the purpose of remedying this situation, a research laboratory has been established by the American Society of Cinematographers in Hollywood,⁶⁷ to make authentic tests on standard cinematographic subjects,

The question as to whether Roentgen cinematography can become a current method of research has been considered.⁶⁸ A new indirect method has been suggested which consists in placing a screen of selenium cells in the path of the X-rays, with each cell in an individual circuit and connected to a lamp. A curtain made up of such lamps will give a picture which can be photographed.

For some time the Cleveland Public Library has cooperated with exhibitors, advance publicity men and the distributing offices in New York City in maintaining a film library.⁶⁹ The method of cooperation is so arranged that lists of films coming for a year ahead are on file in the Order Department of the library, and in the various book divisions likely to be affected by them, months before the making of the film has begun, enabling the library to list book connections and purchase in season the books needed to supply the demand created by this library-film cooperation. It makes possible the careful reading of books and plays to be filmed, to discover all the book connections.

Illuminants and Lighting Effects.

The adoption of panchromatic film is leading to the increasing use of incandescent lamps in studio lighting. The incandescent light source emits light of all colors, but is strong in reds and yellows, and is therefore especially adapted to use with panchromatic film. The elimination of so-called "Klieg Eyes," attributed to exposure to light from carbon arc lamps, is reported⁷⁰ by a large producing organization which employs incandescent lamps and panchromatic film.

A study has been made in France of the proper illuminants to use in the cinematographic studio.⁷¹ The use of the blue and ultra-violet arc was found to be injurious to the actors, and screening out the ultra-violet reduced the photographic efficiency to an impracticable value. A flame arc emitting a greater proportion of visible radiation, or gas-filled tungsten lamps operated over voltage, and used in conjunction with orthochromatic or panchromatic film, are preferred. The use of panchromatic film and one of these light sources eliminates the complications of "make-up" and choice of colors in scenery.

A new high intensity projector arc lamp has been introduced⁷² which is designed for very high amperages. It has a new feed assembly and greater forward adjustment. A combination high intensity flood lamp and single effect projector has been developed which is adapted to extremely long projection distances.^{72a} It consists of a high intensity arc lamp and a single optical system provided with projection lenses

of different focal lengths, effect holders, etc., all easily swung into place. A French invention in arc lamps for projectors utilizes a single carbon which is of small diameter and lies horizontally, feeding toward the condensing lens.⁷³ The negative electrode is a metallic ring, and the arc is formed between this ring and the carbon. The light is said to be extremely brilliant, steady, and cooler than the usual arc. It is also claimed that with equal screen brightness a current economy of 50 per cent is obtained.

A three-carbon arc has been developed⁷⁴ in which one of the carbons is placed just above the positive crater. After the positive carbon burns away, the flame touches the third electrode, causing a magnet to be energized and to feed the positive carbon forward. The flame then ceases to act on the third electrode.

One author, in describing a new condensing lens system, erroneously states that with mirror arcs, 60 per cent of the total light flux may be projected to the screen;⁷⁵ a figure of less than 10 per cent would be more nearly correct. He states further that with typical condensing systems only about 3 per cent of the light reaches the screen. The Bausch and Lomb relay system is then described, and it is stated that while it collects less light than does a mirror, it utilizes more efficiently that which it collects. A patent has been granted on an optical system consisting of a reflector and special condensing lenses, one having a small negative lens inserted at its center.⁷⁶

A discussion has been published⁷⁷ of special lighting effects used in taking night scenes, with special reference to the relation between the amount of general and local lighting.

Laboratory Equipment and Apparatus.

Three methods used in printing motion pictures are the step-by-step, the continuous, and the optical whereby a lens is employed to carry the image of the negative to the positive. In a paper presented before the last meeting of the Society, a daylight optical printer for the reduction of standard size negatives to 16 mm positives was described.⁷⁸ In another paper presented at this meeting, a description was given of four different motion picture printing machines, and of their operation.⁷⁹

There is a new process for film regenerating consisting of an apparatus divided into three compartments;⁸⁰ the film is first cleaned by brushes, then passes into the second compartment where it is exposed to the vapor of a mixture of acetone, acetic ester and such

softening agents as camphor, phthalic acid ester, nitrobenzol, etc. In the last compartment the film is polished. All scratches and abrasions are removed by this process.

An illuminated box has been designed for the direct inspection of motion picture film.⁸¹ The lamp housing is at one side of an inclined film gate and a prism reflects the image of the film to an observing window.

A pneumatically controlled machine has been developed⁸² to test motion picture films for slits, breaks and holes. A selenium cell and an electrical circuit has been used as a means of measuring, by light passed through motion picture film, the density of the film for printing.⁸³

Lenses.

Lenses are being designed to work at faster speeds. The F/1.6 objective lens is now quite common.⁸⁴ Tables have been compiled showing the depth of definition for 35 mm, 42 mm, 50 mm and 75 mm objectives at apertures from F/2 to F/9 inclusive. A lens manufacturer has applied for a patent on a lens with an anastigmatically flattened field freed from coma and flare, and working at the large aperture of F/1.4.⁸⁵

A study has been made of the relative characteristics of a motion picture positive and its screen image with reference to the effect of projection lens flare upon the contrast of a motion picture image.⁸⁶ It has been concluded that the veiling brightness due to flare is directly proportional to the average transmission of the projected positive; that the flare-forming characteristics of a lens may be expressed as the ratio of the flare brightness to the average brightness of the picture; that the effect of flare upon the characteristics of the picture can be computed from a knowledge of certain characteristics of the positive; and that the effect of lens flare on quality of tone reproduction is to warp the shape of the reproduction curve and depress the contrast.

New Applications.

The possible applications of motion pictures are without number. New uses are continually being found, most interesting of which are those that serve to promote the general welfare of human beings. At the Montreal convention of surgeons, Mr. Will Hays outlined the advantages of motion pictures in helping physicians teach the value of health and the importance of proper living.⁸⁷ He also pointed out

that the use of motion picture will preserve for future generations the technique and operative skill of eminent surgeons of the day, bringing the work of these masters to students in every part of the world. Physicians are planning to use motion pictures in conducting a bacteria war.⁸⁸ Films of bacteria and animalcules are claimed as made possible by a recent development for separating the heat waves from the light.

The practical difficulties encountered in the taking of wildbird and wild animal motion-pictures, and the solution of these difficulties⁸⁹ was the subject of a paper on the use of the telephoto lens presented before the Society.

Motion photomicrography has been left largely to a few specialists because of technical difficulties about which little has been written. However, with a little serious application, the principles involved may be readily grasped. An extensive paper was presented⁹⁰ at the last meeting of the Society upon the theory involved and its application to specific samples.

Exposure factors for forest photography have been approximately determined.⁹¹ Though it is impossible to give exact tables, experience has shown that they are as follows: landscape in the open, factor of 1; leafless woods, factors of 5; leafy hardwood stands, open pine stands, factor of 25; open hemlock stands, factor of 75; open pine stands, dense foliage, 200; dense pine stands, dense foliage, 1000.

A specially constructed twenty-ton motion picture camera was used to film Saturn and his rings from the Yerkes observatory on January 28.⁹²

Immigrants may now have some knowledge of the ideals of the United States before they set foot on American soil, through the use of films displayed on ship board.⁹³ A large commercial line has inaugurated an Americanization program of films for aliens on one of its ships.

Physiology.

The question as to whether or not motion pictures are harmful to the eyes has been discussed by a Philadelphia doctor⁹⁴ who contends that there can be no sweeping answer in the affirmative or in the negative. He says that while for a few the movies are a positive menace and for many they are a source of discomfort and annoyance, fortunately for the majority of people they are not harmful, as has been alleged, though not particularly beneficial to the eyes. He discusses

the factors which may cause annoyance and discomfort and suggests possible remedies or helps. In general it appears that pictures in natural color are much less conducive to eye strain than those in black and white. Among the questions which have been studied⁹⁵ are "memory color" phenomena, depth effects, and hygienic aspects.

The action of the heart has been studied with the Röntgen Cineomatograph.⁹⁶ Full size 8"×10" radiographs of the heart were made serially at a rate of 15 per second.

Projectors.

The usual number of patents are being issued on various devices for the improvement of projection and the problem of continuous projectors is still in the good graces of inventors. The high intensity of illumination at the aperture, the noise of operation, and the rapid wear and tear of films with the intermittent motion picture projector have caused many attempts to utilize a continuous motion of the film. Practically all of the devices proposed or developed to the present time have been much more ingenious than practical. A continuous projection apparatus and camera have been developed⁹⁷ which are based upon the fact that if two mirrors are arranged as in a single periscope and if the exit mirror be given a proper rotation around an axis perpendicular to the axis of the tube, the motion of a point in the image can be compensated.

At an exposition of photography and cinematography held in Berlin recently, an amateur motion picture camera was shown which had a time release controlling the spring drive, permitting the operator to appear in the picture.⁹⁸ A motion picture projector having automatic lubrication, and feed roll friction controlled by the weight of the film roll; and a Mechau projector which operates as slowly as two frames per second without flicker were also demonstrated.

A Frenchman has developed a tiny moving picture projector which is no bigger than a cigarette case⁹⁹ and which, it is reported, can project pictures as large and clear as ordinary ones!

A leading model standard projector has been improved¹⁰⁰ by the incorporation of mechanical in place of electrical speed control, a miniature framing lamp, an automatic loop setter, and an improved stand. A projector has been designed having a governor which controls the number of filaments lighted in a special lamp and also the speed of the film movement.¹⁰¹

Another shutter has been devised which, it is claimed, produces flickerless pictures.¹⁰² The shutter blade has a transparent rippled surface and is preferably used with a supplementary light so that some illumination may be directed to the screen while the film is moving.

Patent activity in the field of safety shutters has turned from the use of air blasts at the film gate to the use of various safety shutters and other fire preventatives.¹⁰³ A device for reducing the light when a motion picture projector is stopped to project stills has been designed.¹⁰⁴ A notch in the film engages a movable projection which controls a switch that throws resistance into the lamp circuit. It is also operated when the speed of the mechanism is reduced. In another safety device a film roller breaks the motor circuit when the film breaks or fails to run through the machine,¹⁰⁵ and a film magazine has been devised which has a small drum of noninflammable gas connected to it.¹⁰⁶

Fires should be localized in the projector itself and not in the projection room, and it is said that British legislation may make fire traps compulsory on projectors.¹⁰⁷

A new safety device which renders impossible a fire in the projector is said to be perfected.¹⁰⁸ It has nine control stations at the various sprocket wheels and belts, and an electrical system whereby a break in the film, buckling, blowing of the fuse, etc., will instantly throw a lamp house dowser. Should the system fail to work, the mechanical features of the invention function and the failure of the film to properly pursue its course instantly shuts off the power and throws the dowser.

In projection it is often important to get as much light as possible through the film aperture, but it is also necessary to consider the temperature of the film surface at this point. With the introduction of the mirror optical systems, in which the heat at the aperture is very much more than in the case of lens systems, this necessity has come more into prominence, and the relation between the temperature at the film and the useful light flux has been given new study.¹⁰⁹ It was found that the temperature in the case of a metal mirror was almost twice as great for a screen illumination of fixed value as that produced by a system employing a glass mirror and condenser. This ratio was somewhat less for a screen illumination of double this value. A theoretical loss of 28.6 per cent of available flux was measured in a condenser system composed of a glass parabolic mirror and a con-

denser of 50 cm focus and 20 cm in diameter, which was due to absorption and dispersion. The effect of the brightness of the light source and of the cooling mechanism was also included in this study.

Comparative temperature measurements in the aperture of motion picture projector gates have been made from measurements of the resistance of a blackened wire in the gate,¹¹⁰ and Odencrants' experiments on the temperature in film gates have been summarized.¹¹¹ An opaque black body placed in the gate is the standard receptor. Film during normal travel through this region should not reach a temperature of 90° C though its inflammation point is about 155° C.

Screens.

A very complete analysis of the reflection characteristics of many commercial projection screens was presented¹¹² at the last meeting of the Society. Tables were included which may be applied to particular problems in selecting the proper types of screens for auditoriums and theaters.

A semi-specular screen has been made from paint, aluminum and gilt spangles and used in some large London theaters.¹¹³ This screen is found to give a strong axial reflection without rendering the picture dull to patrons in the front and side seats.

A paint has been devised for motion picture screens¹¹⁴ which contains small amounts of color. These, it is claimed, do not visibly alter the whiteness of the screen coating but are "responsive" to color in the projected beam.

More perfect reproduction is said to result through the use of a projection screen including a transparent plate having fine sinusoidal corrugations formed on its display side and covered with a semi-opaque varnish layer.¹¹⁵

A translucent screen has been devised for daylight projection¹¹⁶ which has one face polished and the other, which faces the spectators, matte and dark. Dark coverings have been arranged both behind and in the front of a translucent screen to permit the passage of projected light and to obstruct dispersed light.¹¹⁷ The front covering may be a black net having its vertical threads more widely separated than the horizontal ones.

Statistics.

Exports of motion picture films during 1926 were somewhat less than during 1925;¹¹⁸ 214,026,620 linear feet of positive film valued at

\$6,395,923 were exported during 1926 as compared with 225,656,151 linear feet values at \$6,787,687 exported in 1925. Negative film exports in 1926 amount to 6,600,000 linear feet valued at \$1,334,960 compared with 9,929,643 linear feet, valued at \$1,893,058 exported in 1925. Latin America during 1926 led the foreign market for American films from the standpoint of quantity, however, Europe led from the standpoint of value. Australia was the largest individual market for our films in 1926, with Canada as second largest and Argentina third. From these figures the negative film was valued at 2.02 per linear foot and positive film 2.98 per linear foot.

Twenty thousand miles of film were used during the year 1926 by amateur motion picture makers.¹¹⁹ It is predicted that considerably more will be used in 1927.

A two-year survey conducted by a current magazine indicates that there were 14,991 motion picture theaters in the United States in the year 1926.¹²⁰ This is an increase of 306 theaters over 1925. There are 2,000 first run theaters.

According to figures compiled by the Census Bureau, motion pictures produced in the United States in 1925 cost almost \$100,000,000.¹²¹ This figure is considerably higher than that compiled in 1923 when the first census was taken. It was reported that there were 5,945 salaried officers and employees of the industry in 1925. The salaries for the year totaled \$35,950,778.

The total seating capacity of motion picture theaters in this country has been said to be 18,500,000 or one seat for every six persons.¹²² A large seat corporation reported sales for the year in excess of \$10,000,000.¹²³

During the past year twenty companies have been organized for the purpose of producing motion pictures in China.¹²⁴ There are at present approximately fifty companies producing pictures there, not more than 10 per cent of which are on a paying basis. It is reported that there are about 106 theaters with a total seating capacity of approximately 68,000. Motion pictures are also shown to a certain extent in educational institutions and lecture halls.

A motion picture film producing organization has been formed in Burma¹²⁵ and is composed entirely of natives. The studio, which is in a secluded part of the Burmese jungle, is entirely up-to-date. They have already produced eight pictures dealing with Burmese life which attract Europeans as well as natives to the theaters.

The United States Navy is said to be the largest motion picture distributor in the world.¹²⁶ Simultaneously with the release of features to the large theaters, the navy starts two prints on circuits on which the films travel three years before returning to storage, the reels going from ship to ship until every vessel of the fleet has had its turn, then, after overhauling they go the rounds of the naval stations. Motion pictures are also used as an added inducement to join the Navy.

Stereoscopic Projection.

It is rather difficult to determine just what actual progressive development has been accomplished recently in plastic cinematography. Reports of perfected apparatus to produce this effect are widely distributed, and it is certain that there is much interest in this field. An analysis of the principles involved in stereoscopic and pseudoscopic projection, and a résumé of various means and methods which have been tried and patented, were given in a paper presented before the last meeting of the Society.¹²⁷

It has recently been claimed that actual third dimension pictures showing length, width and depth on the screen are an accomplished fact, and that photoplays made by a new process will be available for all theaters regardless of size or equipment without making any changes in the theater whatever.¹²⁸

A new binocular stereoscopic camera has been developed and is regarded by its inventor as one that portrays pictures in the true three dimensions.¹²⁹ When pictures taken with this camera are viewed through a special appliance, the screen seems to disappear and there is no consciousness of a picture having two dimensions, exposed on a flat surface. The success of the camera is said to be explained by the theory of binocular vision.

A patent has been granted on a motion picture apparatus for producing pronounced relief effects by giving the taking apparatus a constant to and fro motion along a straight line and causing it to move from left to right, front to rear, and top to bottom,¹³⁰ and another patent has been issued on an apparatus which obtains an effect of relief by taking alternate pictures under different lightings.¹³¹ The motion picture camera is connected to a light control that causes the lightings to alternate in synchronism with the exposures.

Talking Motion Pictures.

The talking film is at the present time popular because of its novelty but it will undoubtedly be used extensively in the future to

replace orchestra and vaudeville parts even if the talking play does not become popular.¹³² While early motion pictures were shown without music and technical and travel pictures of today are still impressive in silence, the modern audience requires music synchronized emotionally with the subject matter, with a background of perfect silence.¹³¹ A survey of the present progress in the art of "Talking Pictures" has been published in a European magazine.¹³⁴

A new device for furnishing incidental music for the picture, called the "Remaphone," has been developed.¹³⁵ It consists of a Victor "Electrola" with two turning tables connected by a shaft to the two projection machines in the booth. Perfect synchronization of picture and music is said to be obtained. Another apparatus, called the "Photophone," has been perfected. It is a combination of a motion picture projector and the pallophotophone.¹³⁶ The pallophotophone makes a photographic print by means of a vibrating beam of light on a strip of film, and when the film is run through the reproducing machine the vibrating beam of light retranslates the photographic sound record into audibility and is amplified by a loud speaker to any degree desired.

A new mechanism made under the Vitaphone patents carries the sound waves on the film,¹³⁷ thus making it impossible for the sound to become out of synchronization with the action of the picture. "Movietone" pictures is the trade name given the device, which is operated with the Vitaphone mechanism.

Instructions for the operation and maintenance of the Vitaphone synchronous reproducing system have been published¹³⁸ for the benefit of the projectionist. A motor switch, a volume indicator, two amplifiers, an equalizer for improving quality of reproduction, and a general power supply panel are essential to start the film and sound record in synchronism. Either alternating or direct current may be used.

It is claimed that the tone of the sound reproduced from a photographic film record may be improved by reproducing the sounds at least twice in such a manner that they reach the ear with a phase difference corresponding to a time interval of $1/8-1/30$ of a second.¹³⁹

Some effort has been directed among producers toward standardization of sound reproducing devices.¹⁴⁰ The adoption of different systems by each producer is said to restrict competition since producers will eventually be limited in their business to those theaters using their own system, and the theaters will be limited to dealing

with producers having the system corresponding to their own particular device.

An experiment was recently made in Germany in which film and radio were synchronized for the transmission of a scientific medical lecture to a motion picture audience.¹⁴¹ The transmitter and the projector at the sending station were connected with a synchronometer, and the same arrangement was carried out in the theater, thus causing both motors to run at exactly the same speed.

Television.

Paralleling the efforts made toward perfection or improvement of talking and stereoscopic pictures is the continued activity toward the development of a practical device to transmit still and motion pictures by wire and by radio. It is predicted that within the next ten years, we may sit at home and see motion pictures flashed on a screen through use of the radio.¹⁴²

A method is being developed which, it is reported, will accomplish instantaneous transmission of pictures.¹⁴³ The transmitter employs a Kunz photo-electric cell and a four-electrode amplifying tube. The receiver uses a Braun-tube, which automatically insures synchronism. Twenty pictures are sent per second which insures continuity of vision.

Infra-red rays have been used recently in London to transmit the images of the faces of people sitting in a dark room to a screen fixed in another room, also dark.¹⁴⁴ The inventor of this apparatus believes that in another year it will be a commercial proposition, retailing for \$150.00. It will enable users to see and hear at the same time when used in connection with either the telephone or wireless.

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DISCUSSION

MR. GREGORY: In reference to the cine objectives, there are now two firms that have actually manufactured and are offering lenses of the claimed aperture of F/1.5. Mr. Minor, of Los Angeles, and some German makers are offering them.

MR. GRIFFIN: In the report it is mentioned that ideal projection is being obtained in absolute darkness. The screen, mentioned in the report, will exactly reverse this procedure; the best projection can be obtained in a brilliantly lighted room.

MR. RICHARDSON: I might add that I have seen the picture, referred to by Mr. Griffin, projected. I stood in front of a well-lighted window, within 6 or 7 feet of the window with sunlight outside and saw the picture very well indeed. It is proposed to project a perfect 18 ft. picture with a lens of 2 in. diameter of less than 1 in. equivalent focus, and I think it will be done.

MR. GRIFFIN: It is very easily perceptible; if the house lights in the theater are put out, the picture becomes very poor, and if the lights are put on, it becomes much brighter.

MR. JENKINS: I should like to ask how the information with regard to the pictures by reflection of infra-red rays was obtained. Is that a fact or something picked up? I understood that pictures had been projected through a lens with infra-red rays.

MR. EGELER: I believe you have in mind projection with regard to television. My information on most of this is obtained from references, and these are given in the report.

The Board of Governors decided that a file of the TRANSACTIONS should be bound and placed in the custody of the Secretary. Another bound file was to be placed in the library of the Engineering Society. It was found, however, that no copies of Nos. 1, 6 and 9 were among the back numbers in the possession of the Society, and an appeal was made at the Spring meeting for copies of the same. Two copies of Nos. 6 and 9 have since been presented to the Society and it is earnestly hoped that two copies of No. 1 may also be obtained. Should any member have surplus copies, or does not place great value on his copy of this issue, the Society will gratefully receive the same.

REPORT OF ADVERTISING AND PUBLICITY COMMITTEES

THE Advertising and Publicity Committees were combined this year and it is obvious that this has meant considerably more work for those on the single committee. In spite of this, however, and many important changes in the equipment field which have reduced the number of concerns who helped us out in the past, the amount of advertising in the TRANSACTIONS compares favorably with that printed other years. All advertising in the TRANSACTIONS is given as a matter of good will and members of this organization are asked to help the Committee in the work of securing advertising for our publications. Personal solicitation by members of the Committee is a difficult matter and letters are cold and ineffective. The Society needs the funds secured through publishing a limited number of advertisements in the TRANSACTIONS and if our members will say a good word for us the advertising departments of the companies they represent may be more willing to take space in our publications. The companies who have taken space are entitled to the appreciation of this Society and the Committee hopes that members of the S.M.P.E. will do everything possible to reciprocate.

No systematic record has been kept of the publicity secured for the Society but the Committee believes that the officers and members of the organization are aware that the trade publications are devoting considerably more space to the work of the S.M.P.E. All these publications printed full accounts of our Conventions before and after the Fall meeting and have already published the full program of the Spring meeting. Some of the trade publications print papers from the TRANSACTIONS in full and we hope to be able to supply abstracts of the papers read at this meeting so that they will become part of the news section of the trade publications while this meeting is in session. It is apparent that the motion picture industry is beginning to realize the value of the work of the S.M.P.E. and with the increased willingness of the Society to receive suitable publicity, your Committee has been able to work more effectively along these lines.

The Bulletin is also issued by this Committee and members of the Society are requested to make the fullest allowance for its shortcomings. The work of issuing a Bulletin for this organization was entirely new to us this year and a four-page leaflet issued four times

a year does not offer much opportunity for giving the variety of information that insures the interest of all members of the Society. For a time it is difficult to secure any items and then at the last moment when the Bulletin is almost made up more good material comes in than we have space for. If the Bulletin is too formal there is a loss of interest and on the other hand this Society cannot very well afford to have the items published of too light a nature. Your Committee hopes to have the Bulletin issued six times a year to contain interesting information, official communications, the list of members and other printed material which does not properly belong in the TRANSACTIONS. With these six issues of the Bulletin, four issues of the TRANSACTIONS and two semi-annual meetings, members could be kept in touch with the Society practically every month of the year. It is important that contacts be kept up in this way as it is even more necessary for us to retain the interest of old members than it is to secure new ones. It is, of course, our hope that the Bulletin and other activities will help us secure new members for replacement and growth.

While it seemed logical and correct to combine the Advertising and Publicity Committees as their work apparently lies along the same lines, your Committee is not so sure that the plan is an entirely satisfactory one. Solicitation of advertising and preparation for publication require considerable persistence and attention to details. Publicity work demands enthusiasm and some play of the imagination. The qualifications necessary for securing advertising and publicity are not always combined in one individual and it is probable that better work in both of these departments could be secured if the Committees were again placed under different heads.

P. A. MCGUIRE, *Chairman*
A. M. BEATTY
LOUIS COZZENS
GEO. EDWARDS
W. V. D. KELLEY
J. C. KROESEN
JOHN H. KURLANDER

REPORT OF PUBLICATIONS COMMITTEE

ONE of the main difficulties encountered by the Committee is the remoteness of the printers, causing a lapse of at least a week before an answer can be received to any communication. Actually more time has been consumed in the transit of matter etc. than in the actual printing. This entails an inevitable delay in the appearance of the TRANSACTIONS. Some slight improvement has been made in an earlier publication and more important still the root of the previous delays has been run to earth. It is, therefore, hoped that succeeding issues may appear somewhat more promptly after the meetings, particularly with the promised whole-hearted support of the Papers Committee to this end.

Considerable work and time would be saved if authors would observe two simple rules:

1. *Never use single spacing in the typewritten MSS.*

Certain conventions as to spelling etc. are observed and errors are inevitable. These corrections can not be made with single-spacing, unless at least 2 inches blank spacing is left on each margin of the sheet.

2. *Do not send in a carbon copy of the paper.*

No less than three manuscripts had to be retyped because the copy was illegible in parts, mainly through the blocking up of the letters. Compositors are not mind readers nor decipherers of hieroglyphics. That more mistakes did not appear is due to the fact that the reader of the MSS had heard the papers and carried some mental impression as to what was meant. But this means extra work and mental strain that are not conducive to rapid dispatch.

By careful reading of the papers the cost of author's corrections—always a source of irritation and generally disputes between the printer and publisher—has been materially reduced; it is hoped that this may be maintained. To this end galley proofs of the papers were not sent to authors, except in one or two cases. This system will be continued and it behooves authors to see that their MSS really state what they meant. Alterations on galley proof, save correction of mere typographical errors, are not permissible—they cost money.

Notwithstanding the fact that every typewritten copy of the discussions, sent to members taking part therein, bears a statement

that, if the same is not sent within 5 days to the Chairman of the Publications Committee, he will correct and print the same, this has not been complied with by some members. This causes delay and correction in galley proof. This last too, costs money. It is earnestly requested that promptness in this respect be observed by all.

E. J. WALL, *Chairman*,

J. I. CRABTREE

K. C. D. HICKMAN.

REPORT OF MEMBERSHIP COMMITTEE

THE clerical work of any membership committee is interesting and not arduous. Whether a great increase in membership is secured is dependent on the new sources of possible members known to individuals on the Committee. During the past six months only one new source has been discovered and this by Mr. L. C. Porter. Mr. Porter had the great notion of sending in to the Committee the names of all persons inquiring for TRANSACTIONS so that they might be circularized with the Society's literature. At least fifteen new members have been secured in this manner. Of the remainder eight more have come in by introductions from existing members of the Society, and four are in the process of admission. This makes an effective increase of twenty-seven.

During a recent trip to Hollywood Mr. Crabtree and I secured the names of about three hundred technicians, mostly cameramen, who should be interested in our work. Experience early in the year has shown that the mimeographed form letter is instantly detected as such, cordially resented and consigned to the waste basket. These men are, therefore, now in the process of being written to individually and the results, if any, will be reported at the next Convention, thus concluding the year's work. At the moment it is interesting to note that the present increase of twenty-three net for the six months shows a very great improvement on the rate for the last three or four years.

The membership of the Society will probably show a substantial increase owing to the successful efforts of Mr. J. A. Ball in founding a West Coast Section. At the moment we have no information as to the magnitude of Mr. Ball's undertaking, but doubtless a report will be forthcoming shortly.

In conclusion it is interesting to study the appended graph compiled by Mr. L. C. Porter showing the Society's membership curve from the date of its formation till the present time.

From 1916 to 1922 the increase follows the normal law of organic growth. The number of members coming into the Society at any time is proportional to the size of the Society at that time.

By 1922 all the available engineers had been brought in and the rate of growth necessarily falls off. The present new increase is indicative of the Society's excursion into new fields, and growth will probably continue till these too have given their available workers.

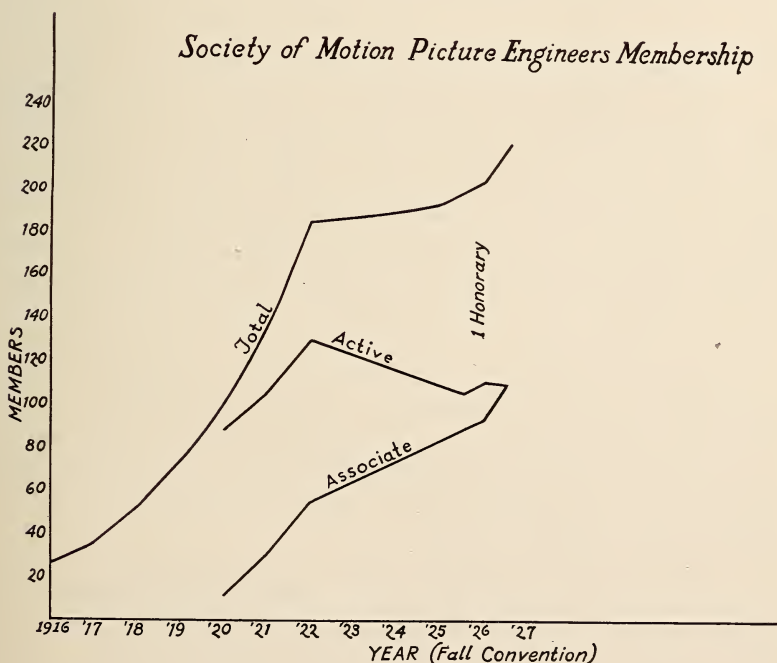
K. C. D. HICKMAN, *Chairman*

JOHN H. THEISS

C. L. GREGORY

W. C. VINTEN

F. H. RICHARDSON



HOLLYWOOD AND THE MOTION PICTURE ENGINEERS

K. C. D. HICKMAN*

A GENTLEMAN (not myself) recently obtained an interview with the manager of a large picture corporation in Hollywood. He explained to his host that while the corporation's films were excellent, everything about the business direction and technical economy was bad; that this should be altered here and that changed there; that one man required dismissal and that another should be elevated to a position of command; finally, that what the company really needed was an engineering economist, of first class ability and reputation (himself) to set and keep things in order.

To this the manager replied that half an hour previously the need for an economic expert had existed but his visitor's exposition had been so clear that all could be put in order without further trespassing on his time. The visitor departed a sadder and wiser man.

This incident is typical of many. In spite of its isolation the wealth of Hollywood is such that people, important people, gravitate there from every corner of the world. They all want to induce the established powers to exchange part of their wealth for some commodity—ideas, service, or interest—that they have to peddle. And the universal method of attack appears to be disparagement of things. Therefore, without having to step outside his office door, much less outside of Hollywood, the company manager is made aware of every stunt, wheeze, or charlatanry relevant or irrelevant to the industry. Instead of having to establish contacts, his concern is to secure sufficient seclusion to get on with his job. Nor does the bombardment stop at interviews. The movie journals and magazines are alive with articles by publicists, novelists, and the louder species of technician describing the errors of prevailing practice. In this sense, therefore, the isolation of Hollywood is legendary.

There is, however, a humbler class of individual who drifts West doing the same real thing, looking for a job but without the blare of trumpets heralding revolution. Now it happens that in Hollywood the laws of supply and demand are curiously reversed, inasmuch as there is an indefinitely great supply of technical and artistic labor and obviously a strictly finite demand. Yet salaries remain at an inflated

* Research Chemist, Research Laboratory, Eastman Kodak Company.

level. The explanation is that the demand is for the *best*, always a select minority, and not for the cheapest. The trouble arises when one tries to assess the best. The best is often that which *is* rather than that which is purely speculative. The man that has a job has a means of expressing his ability and is therefore a more valuable commercial proposition than the man, be he ever so clever, who has no job and therefore temporarily no means of demonstrating his ability.

It follows that from the point of view of personal safety, silence and a certain measure of secretiveness is the first elementary protective conduct of the successful movie technician; since during mere argument the man without a job fights on the same plane as the man in possession of one. Also, since there is keen rivalry as between studio and studio, reserve must be practised over technical working details. It is indeed a great tribute to the technicians that in spite of the immediate danger many are long-sighted enough to speak openly of their work, that bread cast upon the waters may return to them and their brethren after many days.

From these disjointed remarks we may deduce an interesting state of affairs. While the whole world, whether from interested or altruistic motives is shouting advice to Hollywood, Hollywood herself is maintaining a discreet silence except in the legitimate business of advertisement. The world is telling Hollywood what Hollywood should do for the good of itself and the world; Hollywood fears to do anything but remain silent in telling what she will need next year for next year's films; because each unit in telling the world will be telling neighboring units, each technical man would be telling his brother competitor.

In saying that the whole world shouts at Hollywood one must except a small but photographically important class to whom deeds mean more than words and whose very work precludes propagandist trips to the Coast. I refer to the photographic scientists; the chemists, physicists, engineers, and opticians, the whole range of technical specialists in fact who at present constitute our Society of Motion Picture Engineers. You, who may claim to have more real knowledge to impart than boat loads of stunt merchants, are entirely out of touch with the people who consume the physical products of your brains. Out of touch in every medium save salesmanship, which professedly makes no attempt to convey scientific knowledge.

Why do we want to keep in touch with the Coast? The answer is because we provide the raw materials of picture making; because our

livelihood, our right to live (to use a fashionable phrase), depends on our ability to fill the movie man's needs in an ever expanding degree. To do this we have to do two things. We have firstly to disseminate continually and all the time general scientific knowledge, together with that practical instruction so prized by the field worker; and secondly, we have to get the other man to describe his business so that we may anticipate his needs of tomorrow. This is not a kindness nor even a duty. It is a commercial act as necessary as advertisement to a soap manufacturer. It is in no sense sinister but incorporates the best ideals of your Rotarians by securing mutual benefits from mutual interchange. *We* know this. The people out at the Coast don't.

First of all, the few that have heard of us laugh when we call ourselves motion picture engineers. As well call the President the man who furnished the White House. We merely furnish the tools for the motion picture engineers. The real motion picture engineers may be seen in and around the studios and laboratories in Hollywood; men whose names do not appear in our TRANSACTIONS. I should like to call them *primary* motion picture engineers and ourselves *secondary* motion picture engineers. This classification does not attempt to state their order of precedence, merely their order of function. Our present problem is to bring these two sides together and under the aegis of the Society.

A short time ago the Chairman of your Papers Committee and I had the pleasure of spending a holiday in the West and being introduced to a large number of technical men and their parent organizations. Naturally we took every opportunity of urging membership by describing the Society's activities. To our pleasant surprise we found the ground had already been well covered by Mr. J. A. Ball, who had found a great deal of sympathy from the officials of the Motion Picture Producers and Distributors of America who promised secretarial and other help.

All this is very much to the good, but nevertheless in our development we have to be very jealous even in our friendships. No young lady can receive a fur coat from a male friend without criticism even though everything *may* be alright. Therefore, though we have faith in every friendly overture, we must inquire what "Quid pro quo" will be demanded. I have said that firms on the Coast are being bombarded continually with men and inventions purporting to work miracles. An ever-present problem is the sifting and weighing of these ideas so that the good may be retained and the bad rejected. The

belief was expressed by a number of men to whom we talked that the S.M.P.E. in an enlarged and perhaps subsidized form would be the platform for technical court martials.

This is not the first time we have heard the idea. The matter was debated very thoroughly in the discussion of Mr. Martin Quigley's paper at the last Convention. Suffice to say that the selection of the profitable from the useless, or more vulgarly "picking the winner" is the essence of business success, and the ability to do it is a valuable and highly paid quality. The firm to which I have the honor to belong has a staff of some hundred scientifically trained men presided over by a man of world-wide reputation whose job amongst others is to do this very thing—pass judgments. Yet I doubt if even he would care to make authoritative statements on the value of inventions to a third party. If the Society undertook such a function it would at once become a business institution of unlimited liability in which each individual member, be he ever so humble, would share equal responsibility with the most prominent. He would be open to attack, prosecution, bribery, and every imaginable nuisance. Further, the Society would lose the most valuable asset of any living organism, *freedom*; would, in fact, cease to be a learned Society and become the instrument of the industrial group wielding at any moment the greatest power.

Let us summarize therefore the things we want and balance them against our limitations:

1. We want an increase in membership because it gives us greater financial stability and freedom from heavy patronage;

2. We want to draw the increase from the men engaged in *primary* motion picture work;

3. We cannot expect these men to *publish* freely in our TRANSACTIONS because they are concerned with private technique rather than with fundamental science;

4. Hence, at present the only blessing we have to offer them is the doubtful one of *reading* our TRANSACTIONS, a blessing they could obtain at half-price by remaining non-members;

5. They have, therefore, to be sold on the other aspects of membership; such as the ability to meet, make friends, and exchange ideas as between the primary and secondary types of motion picture engineers;

6. Since these abilities do not at present exist, our problem is to commence their manufacture.

Now, I ask you, unless we are very careful, will a West Coast Section alone meet the bill? If it remains a meeting ground for local technical battles, to be argued in private, and with no avenue for printed ventilation, it may serve a useful purpose but it would be no more affiliated with the Society than, say, the A.S.C. Since also it will have to retain part at least of its subscriptions for its own expenses, we might become entirely unconscious of its existence. We should then have been responsible for starting even another organization and served the cause of separatism rather than unity.

To prevent this unhappy state of affairs, I can see only three remedies, two of them difficult and none of them novel.

Firstly, *précis*, if not verbatim reports of all the discussions and talks occurring in the local section should be read at our Conventions and published in the *TRANSACTIONS*. This takes care of the manufacturing East sensing the needs of the user West.

Secondly, at least one Convention in three should be held at a point so far west that the burden of getting there would be about equal from either California or New York State. And as a start off, even at the risk of a sadly depleted attendance from the East, a Convention should be held right in Hollywood.

The third suggestion is an old one revamped, and concerns the tutorial lecture. Where competition is so keen it is obvious that only technical men of some outstanding quality can occupy key positions in Hollywood. Yet it is a sad fact which they themselves are only too ready to admit that their knowledge is of a very empirical variety acquired by the pinch and handful methods of trial and error. Anybody who will stand up among them and give them quite elementary talks on, for instance, the inverse square law and stop values, or the nature of emulsion sensitiveness, which the research man erroneously believes to be common knowledge, meets, as we have found by pleasant personal experience, the warmest gratitude. There is no need to stress this aspect because our present program contains two or three papers expressly to meet the need.

During the writing of this rather trite survey it has been pointed out to me that in things human as well as in things mechanical there are certain natural tendencies and striving to curb nature gives little result and much friction. I am fully aware that if there is a natural gravitation of West Coast men to their own center any attempt of the parent body to force an artificial unity will be productive of nothing else than bad feeling.

However, we are men, and not fractious children, and we should realize the benefit of some sort of unity over and above the natural desire to be kings in our own castles.

Therefore in penning this plea it is in hopes of being read by one or two at least of our new friends as well as being heard by our old members. It is a plea to temper any new policies of self-determination with a profitable co-operation.

DISCUSSION

MR. CRABTREE: I think the moral of this paper is to hold a convention in Hollywood. It will have to come sooner or later. We all think we know a little as to what is going on in the industry but we don't unless we have been to Hollywood. The expense of such a trip would not be much more than it is to Norfolk. It would be the greatest advertisement the Society could have. It would tend to prevent the establishment of an entirely separate society in Hollywood, which will happen unless there is more liaison between the East and the West. Incidentally, there is in process of formation, you might say, a much larger society than the S.M.P.E.—what you might call a "cinematic" society—in which the engineer is only in a minority; in other words, the society would include actors, scenario writers, and so on, and engineers. Once that society is established, I don't know where the Society of Motion Picture Engineers will fit. I think it very necessary for this eastern society to consider more thoroughly the matter of holding meetings in Hollywood and of getting more liaison between the East and West.

MR. RICHARDSON: It costs me \$24.00 to come down here and go back; it would cost me many times that sum to go to Hollywood and return.

I have been in Hollywood several times and know that out there they consider themselves as about nine-tenths of the whole entire thing. I once listened to one of the big directors setting forth his views as to the relative importance of Hollywood and the rest of these United States. I gained the impression that outside of Hollywood only very small potatoes grew. I then looked the gentleman in the eye and said: "Yes, you chaps in Hollywood are very important. No doubt of that. But just the same any projectionist in any theater can, and many of them do utterly ruin and bring to naught all your skill and efforts. Your skill and work is all directly dependent upon theater managers and the projectionists for its final excellence in-

sofar as concerns the buying public. Put that in your pipe, friend director, and smoke on it for a while."

Maybe we are the plumbers of the industry, but for the plumbers in real life we would pretty much all die, and without we motion picture "plumbers" and our expert "plumbing" the motion picture industry itself would soon languish and die.

I don't think it is practicable to hold a meeting on the West Coast unless we want to hold alternate meetings, one on the West Coast and one in the East each year, permitting those who can make the trip west or east to attend both meetings. That might be the nucleus of an idea which could be worked out in successful practice. We might even manage two West Coast and two East Coast meetings a year.

MR. PORTER: There seems to be considerable diversity of opinion on this Hollywood situation, but I believe the ultimate success of the Society depends on the formation of a strong section on the Coast. In the development of any industry in its organization you must have co-ordination, standardization, and our Society has done a wonderful work in that connection, but we are reaching the point where the technique of the questionable part of the motion picture industry is getting more or less standardized, and the future of the industry will depend more on the production of the pictures and on the artistic end than on the mechanical means, and I feel there will be an increasing need for a strong section on the Coast and perhaps a decreasing need for the work which we have been doing, invaluable as it is in the early development of the industry.

MR. CRABTREE: We went out to Hollywood with preconceived ideas similar to those which Mr. Richardson has outlined. We were very agreeably surprised, however, to find that we were entirely mistaken as regards the technical man, that is, chief electricians, studio managers, men in charge of miniature departments, cameramen and laboratory men. We found these technical workers to be very modest people and very appreciative of any information which would help them in their work. Their degree of intelligence is of a much higher order than we had anticipated. Of course, most of the fundamental research is being done in the East but much practical research work is being carried on out West. I think that the mental stimulation which would result from a visit to Hollywood would more than recompense every member for the slight extra expense involved.

MR. L. A. JONES: I have a very definite opinion on the subject which I have expressed frequently in the past at various meetings

of this organization. It seems to me that we must face certain definite facts relative to the conditions which exist in the motion picture industry, conditions which have a profound influence upon the future of this organization. The motion picture industry is divided geographically into two parts, there being a concentration of activity in the extreme eastern portion and in the extreme western portion of the United States. It seems to me quite impossible to say that either one of these two groups is more important than the other. They represent different parts of the whole industry and each is mutually necessary to the well-being and prosperity of the other.

I feel very strongly relative to the necessity of drawing into our organization those individuals who are located on the West Coast. I feel that this is absolutely essential to the continued well-being and growth of the Society of Motion Picture Engineers. The question then is how can this be done. It seems to be quite evident that this entire group can not go out to the West Coast once or twice a year to attend conventions held there; likewise it is quite unreasonable to expect those who live there to come east once or twice a year to attend these meetings. In view of this it seems to me the only thing to be done is to reach some kind of a compromise.

Would it not be well to consider the establishment of a *West Coast Division* of the Society which shall be of equal importance in every way to the *East Coast Division*. It is just possible that those individuals who are located on the West Coast are not enthusiastic about becoming members of a section of a society the control and administration of which is concentrated in the east and which holds conventions twice a year which it is quite impossible for them to attend. I personally feel that I can sympathize with such an attitude. With two divisions each of equal importance and, let us suppose, eventually of approximately equal membership it might be possible to hold one meeting a year in the east and one meeting a year in the west. It is possible that a few members of the western division could attend the eastern meeting and also that a few of the members of the eastern division could go west to the annual meeting of the West Coast division. I realize that this proposal is rather revolutionary. It seems for most of us in the east that we could attend only one meeting of the Society of Motion Picture Engineers each year. The great proportion of technical societies of national scope, especially those having relatively small membership, hold only one meeting per year. I realize that many of us would feel very keenly the dis-

continuance of the present system which enables us to attend two meetings each year. However, if such a procedure is best for the organization as a whole I think it should be seriously considered. With such an arrangement the society would continue to hold two meetings per year and it would be possible for members of either group to present papers or to send papers to be presented at either one or both of the semiannual meetings. Our transactions would continue to be issued as they are at present following each semi-annual meeting. Or it is quite possible that with the additional membership such an arrangement might give us and the increased material for publication that it would be possible to publish more than four issues of our TRANSACTIONS per year. I feel that there is no hope for this society to reach its highest development if we cannot in some way draw into our organization those individuals who are intimately associated with the motion picture industry on the western coast. We must not only get them into the organization but make them feel they are a part of it and just as an important part as those who are located in the east.

MR. RICHARDSON: That is the only really practical suggestion I have ever listened to on this subject.

MR. HILL: I am entirely in agreement with Mr. Jones on the matter that the two sections should be of equal rank. In view of the fact that we cannot attend the Pacific meeting in a body, we should have an official liaison officer. I think it would be acceptable for Mr. Crabtree or Dr. Hickman to do this.

DR. HICKMAN: With regard to Mr. Jones, I may say that I heartily agree with everything he said. I don't want to take part of the credit for his very excellent exposition, however, I must say I had not mentioned holding as many as one meeting a year in the West because I wanted to propose something acceptable to the Society. If the Society is really making an effort to put the West Coast on the proper footing and go out there once a year, I think it an excellent idea.

With regard to Mr. Richardson's remarks I can support Mr. Crabtree. People take you as you take yourself. If you go out there to test the feelings of the Coast, you will find a very hard, resistant front, but if you go out there humble with the intention of being useful you will find the people kind and obliging. They would give us a wonderful reception out there, because we demanded very little of them.

With regard to time and expense, our convention here lasts three or four days: we spend two days of a week-end getting here, and most of us can get back Friday night. But how many of us go back to work before Monday? That same time would cover most of the journey from California. If you start Thursday night, you will get to California for the meeting Monday. I don't want you to think that Mr. Crabtree and I went to California sleeping in ditches or friendly Y.M.C.A.'s. We went at the most expensive time of the year. If we went on an excursion we could go and come back for \$300. You can get good accommodation for \$2 a day. I think it is a practicable suggestion that we go out West.

MR. MCGUIRE: This organization should have more members on the Coast and they should indicate their interest in our work by attending meetings of the S.M.P.E. I am glad to state that as a step in that direction Mr. Cowling who is also a member of this Society is here as official representative of the American Society of Cinematographers, Los Angeles, California. The American Projection Society is also represented through Mr. Lester Isaac, the Photographers of the Motion Picture Industry by Mr. Carl Gregory and the International Projection Society by myself, all of whom are likewise members of the S.M.P.E. This is a new idea which I trust will work out and result in other organizations sending representatives to appear officially, who may or may not be members of the S.M.P.E. I hope that the whole question of holding meetings of the Society on the Coast can be submitted to all our members in order that we may get some idea as to how many would be able to take a trip of that nature. I have no doubt but that most of us would like to go.

MR. RICHARDSON: Mr. Jones expressed my ideas on this. I don't retract one word I said, but my idea is that we should have one meeting East and one meeting West each year. The West Coast men will be able to attend one meeting a year and the western men will then probably maintain membership, but they will not do so with only one meeting in four or five years held there.

PRES. COOK: Like many other matters which are discussed, no one knows what will happen until it is tried out. I think Mr. Richardson reflects the conscious attitude of about 80 per cent of the members here. In my opinion one meeting at the West Coast will settle the matter for all time, less than a dozen members will go and we shall make such a poor showing that the West will realize it is impossible for our membership to meet with them on any

common ground. I appreciate Mr. Crabtree's, Dr. Hickman's, and Mr. Jones' suggestions, but I do not think it will work out.

MR. GREGORY: I am also here as a representative of the International Photographers of the Motion Picture Industries.

MR. RICHARDSON: May I ask a question? Would it not be practical for the Board of Governors to get into communication with the Coast and find out their opinion of the suggestion made by Mr. Jones?

PRES. COOK: We would have to do this in Governors' meeting, and as you are one of the Governors, Mr. Richardson, this would be in order at the next meeting.

MR. PORTER: The general sentiment expressed here today seems to me equal for joint meetings; I don't see why that is necessary. I don't see why the West Coast Division cannot have as successful meetings as we have; I don't see why it is necessary to cover both the East and the West. It is done in other societies, such as the Illuminating Engineers and the Automotive Engineers. I don't think the success depends on joint meetings. I think they can have meetings as well attended and as successful as those here.

DR. HICKMAN: I want to remind Mr. Porter of the American Chemical Society, which has its section meetings, but all serious papers are always at the large national symposiums in gatherings from all parts of the United States.

MR. PORTER: These national meetings to which you refer are made possible by large membership, and that is made possible by interesting local meetings. If we get a large membership on the Coast, the membership will be large enough to support a half dozen meetings. I think your interesting local meetings are the way to get membership.

RADIO MOVIES AND THE THEATER

C. FRANCIS JENKINS*

THIS is not a learned technical paper. I simply am going to tell you about some of the fundamentals of Radio Movies and Radio Vision for home entertainment.

And right here seems to be as good a place as any to begin standardizing the nomenclature of the new art. In our Laboratory we say Radio Vision when we mean seeing by radio, just as it is now common practice to say radiophone and radiogram, when referring to communication by radio. When we speak of wire-carried service we say telephone, telegraph, and television. Such definitions not only seem logical, and are euphonious, but they greatly facilitate accurate understanding in discussion.

Similarly we say Radio Movies, when we speak of radio transmission from motion picture film, leaving the term Radio Vision to apply when we transmit directly from a person or a scene, although the same machine is used in receiving the picture from either source.

And perhaps I should begin my subject by saying that Radio Movies in the home will not hurt theater patronage. On the contrary, Radio Movies will stimulate attendance at the regular picture theater, for the analogous reason that the Victrola increased the number of grand opera patrons. Many of us came more intimately to know and to love the artists of the opera by familiarity with their personalities as recorded on Victrola discs.

And I remember how Mr. Johnson begged the artists to permit him to carry the beauty of their talent to the far corners of the earth, appealing to their sympathy for the sick and shut-ins, and the lonely people of inaccessible places.

Some artists entered the arrangement with misgivings, but to the astonishment of all of them their visible audiences increased with the popularity of their records, at the same time that their record royalties grew to exceed their income from grand opera engagements.

Incidentally, may I refer to the sale by Mr. Johnson, a few weeks ago, of his talking machine interests for twenty-nine million dollars, at the end of twenty-nine years of belief in his idea.

Perhaps it is only incidental to my subject, but I make the observation that people generally fail to notice the fact that a new

* Jenkins Laboratories, Washington, D. C.

invention does not put an old device out of use. Every new invention finds its own field of usefulness while the old one gets added values in other lines.

The coal oil lamp is generally assumed to have driven the candle out of use, yet ninety-five million gross of candles were sold in the year 1925.



VISUAL RADIO HOME ENTERTAINMENT

The time is not very far off now when inaugural ceremonies, ball games, pageants, and other notable events may be seen reproduced in action on a small screen in the home, carried there by radio.

The astounding increase in the use of electric light might reasonably be supposed to have put both oil, and its successor, gas, out of business. But oil was never before mined in such quantity, nor gas used in such volume as now. Oil made Ford a very rich man, because he built a machine to consume an oil product, not as light but as power. Oil also gave our sweethearts the beautiful tints they wear. Made them beautiful so that we would love them; but left some of them dumb so that they would love us.

I think that sometime I will also write a thesis on this subject as touching working people, who too often fear new inventions will make living harder for them. In fact it does just the opposite. Workmen burned up Compton's first power loom; destroyed Whitney's initial cotton gin; and broke up Howe's handmade sewing machine.

It was a foolish thing to do, of course, for these inventions dress the workman better today than ever before, while he enjoys more conveniences and comforts. Why, even the cotton pickers now ride to the fields "in a Fode."

America as a workplace is the envy of the world, and all because America's inventions have doubled the workman's output, shortened his work hours, and given him more of what he buys with a day's work.

So, go easy now, don't condemn Radio Movies; study the history of inventions instead. It isn't going to hurt theater attendance, it will increase it. If one only cultivates in the public a liking for anything, habit will add its saving grace.

Mr. Bryan introduced the telephone to the public by putting free phones in every drug store in Washington, a silent invitation to call up friends. Secretly I think we felt a little pride in using the new invention, and it cost nothing. A year later he put coin-slot boxes on the phones. And then there was a howl for sure. But we couldn't stop using phones, they had found a useful place in our daily habit.

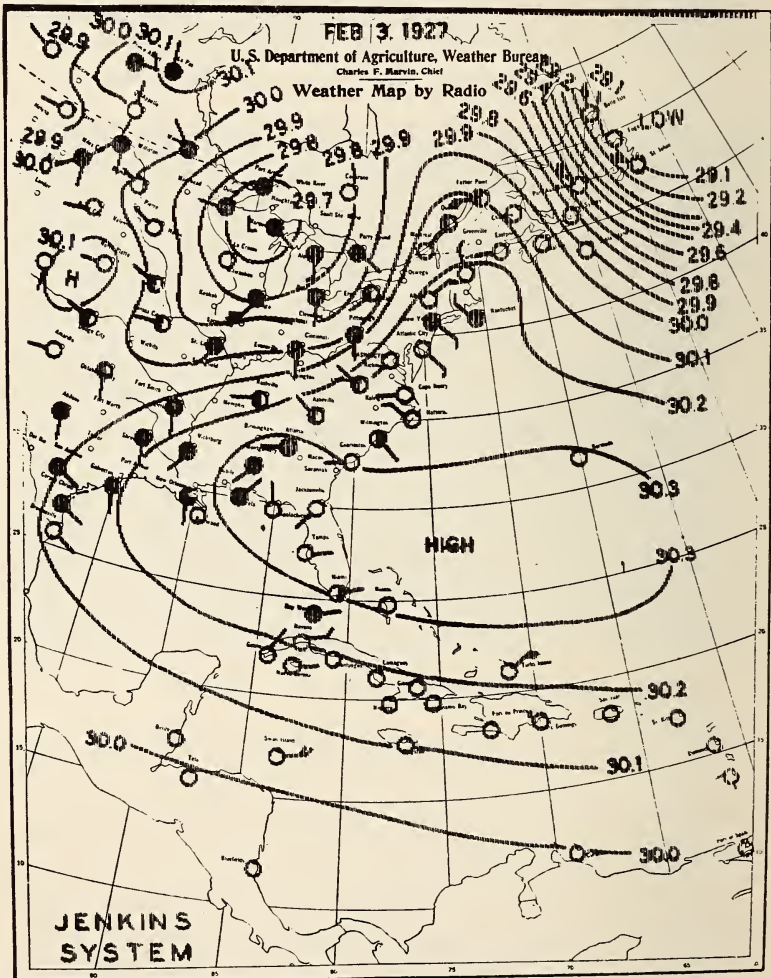
May I take a moment more to cite a case nearer analogous to Radio Movies in the home. Not far from my residence in Washington a picture theater was having a hard time because of poor attendance. When a friend of mine bought it I said to him: "Harry, few people in this section of the city have the picture habit. Give me some pictures to show on my lawn every Saturday night this summer and I will build up a good attendance for you." And that is just exactly the way it turned out.

But to get back to my subject—it is time to give the public Radio Movies for home entertainment. The public is ready; radio is ready; and movies are ready; and every element necessary to complete an acceptable machine is in hand.

So the pioneer should be expected soon. I think he is due now. Doubtless Radio Movies will follow the same program other inventions have followed, like film movies for illustration.

And have you noticed that our own Society membership covers the entire range of the movies growth. There is the pioneer, Jenkins, if you will permit the presumption; then the explorer in the new thing, for example our own Gregory, who shows us the many tricks and avenues of applications possible with movies; Mr. Eastman who refines an essential in the new industry; Mr. Howell who produces splendid tools to work with; Power, Porter and Roebuck who give

us a standardized projector, through the projection aperture of which all the millions and millions of profits have come; then the co-ordinators who make a business of the whole, too many to name them.



Daily Weather Maps are now available to ships at sea transmitted from Washington by radio.

I have no doubt but that Radio Movies will follow almost exactly that program.

And Radio Movies will appeal with the combined mystery of radio and the fascination of the picture story in pantomime, guaran-

teeing a permanent revenue never before equaled, for we all love picture stories, we never outgrow them.

I have no doubt but that the Jenkins Laboratories would have finished Radio Movies last year except for the necessity of developing broadcast Weather Maps, to be picked up by radio aboard ships. This is now an accomplished fact, officially accepted and used by ships at sea and ships in the air.

So it is hoped we may now resume the refinement of Radio Movies. There is no need to wait until some new element or principle is discovered, as has been claimed, for it is an accomplished fact now, and everything we need for its refinement is in hand.

This was conclusively proved when on June 13, 1925, I demonstrated both Radio Movies and Radio Vision between the Navy Radio Station NOF, at Bellevue, and my laboratories in Washington

There were present at this demonstration, as I recall, Secretary Wilbur of the Navy; Admirals Taylor and Robinson, Captains Foley and Tompkins; Acting Secretary Judge Davis, of the Department of Commerce, and with him Radio Director W. D. Terrell; and Dr. George K. Burgess, Director of the Bureau of Standards.

These gentlemen saw on a small screen in my laboratory in Washington, June 13, 1925, what was actually happening at the moment in the Navy Radio shack some miles away at Bellevue, across the river.

A front page description of the demonstration was printed in the next day's Washington papers, the Sunday Star and the Sunday Post, and was broadcast by the Associated Press. It must have gone far, for I had a cablegram of congratulations Tuesday morning from a friend in Paris, France.

And my demonstrations have shown that acceptable Radio Movies are easier to make than acceptable stills, principally because it is the story told in the movie picture, not its technical quality, which attracts.

Perhaps, as engineers, you say: "But, you require such terrific speeds." Certainly, more than ten thousand times the speed for stills. So, as there are limits to mechanical speeds, we adopt the most practical speed for our purpose and then attain the necessary increase in speed by multiplying the light sources, which, sweeping across our screen, make up the picture. Already we have used four light sources, controlled by the pulsing of four corresponding light-sensitive cells at the transmitter; and carried by a single radio wave.

"What, a single carrier. That is impossible." Certainly, I

admit that it is impossible, until one knows how to do it; just as a solid glass prism which changes the angle between its faces was impossible, until the development of the Prismatic Ring.

Sunday Star

WASHINGTON, D. C., SUNDAY MORNING, JUNE 14, 1927

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"Radio Vision" Shown First Time In History by Capital Inventor

C. Francis Jenkins' New Wireless Apparatus Depicts Moving Objects Miles Away—U. S. Officials See Test.

"Radio vision," long the fantastic dream of science, became an accomplished fact yesterday afternoon, with Secretary of the Navy Wilbur and other high Government officials witnessing the feat.

With the aid of a remarkable apparatus invented by the Washington scientist, C. Francis Jenkins, the Secretary of the Navy, Dr. George M. Burgess, director of the Bureau of Standards; Admiral D. W. Taylor, Capt. Paul Foley of the Naval Research Laboratory and others actually "saw" by radio an object set in motion several miles distant in front of a "radio eye" installed at the Naval Radio Station, NRP, at Bellevue, D. C.

It was heralded as the first time in history that man has literally seen far-away objects in motion through the uncanny agency of wireless.

As Secretary Wilbur watched the image of a revolving propeller, selected as the "subject" to be broadcast, as it cavorted on a small screen in the Jenkins laboratory, at 1519 Conner street avenue, he remarked:

"I suppose we'll be sitting at our

desks during the next war and watching the battle in progress."

"That's perfectly possible, Mr. Secretary," the inventor replied seriously.

The demonstration was of a strictly private nature and, in the words of Mr. Jenkins, did not pretend to be a "show."

"It is merely a scientific test that proves we have attained our goal," Mr. Jenkins told his visitors. "By making numerous improvements in our sending and receiving machines we expect to be able shortly to stage a 'radio vision show,' with the talent performing at the broadcasting station and the audience watching the performance at the receiving studio miles distant."

What the officials saw yesterday afternoon was the image of a small cross revolving in a beam of light flashed across a light-sensitive cell at Station NRP. No other objects were used in the test. The image, while not clear-cut, was easily distinguishable.

Director Burgess of the Bureau of Standards, in congratulating the inventor, said: "You've certainly got it, all right, if my eyes aren't deceiving

(Continued on Page 4, Column 6.)

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We also find a fluorescent screen helpful, for its persistence of impression greatly assists persistence of vision. And brief persistence of screen impression is better than persistence of light source alone

for the screen impression remains in its initial position, while persistence of light source moves on and dulls desirable sharpness in the screen picture. Although, in fact we use both methods on occasions.

I have no doubt we could also give you music or speech with Radio Movies, or both sight and sound when in Radio Vision we transmit from living subjects or outdoor scenes, as from beautiful dancers, or an exciting baseball game.

But who wants "talking movies." Except for its transient novelty, *talking* movies will, in my opinion, have no great or permanent attraction for the public. Quite likely recorded music will be substituted for the orchestra accompaniment to pictures.

"Talking pictures" are an anomaly. If the pantomime picture tells the story, please, then, why the talk. It is with murder in our heart that we hear our next seat neighbor tell us what the story is in the picture we are looking at.

All stories, as well as other facts, are recorded in our minds as pictures. It is a picture you pull out of your memory files, not a written description of a boyhood scene or activity. Even when we *listen* to a story we enjoy most the narrator who is the best "word picture" painter.

With our eyes shut we make our best designs, for with lowered eyelids we close the curtains on all distracting scenes, as we build up, modify and finally accept our finished mental picture, before we transfer it to paper.

So we shall not spend time on talking Radio Movies, leaving this work to others, for there are thousands of workers in audio radio. There will be occasions where audible radio will be useful, but they will be few where "talking" movies will be worth the added cost. So as time is short in any event, our task is straight Radio Movies and Radio Vision for home entertainment.

In due course, then, folks in California and in Maine, and all the way between, will be able to see the inaugural ceremonies of their President, in Washington; the Army and Navy football games at Franklin Field, Philadelphia; and the struggle for supremacy in our national sport, baseball.

The new machine will come to the fireside as a fascinating teacher and entertainer, without language, literary, or age limitation; a visitor to the old homestead with photoplays, the opera, and a direct vision of world activities, without the hindrance of muddy roads or snow blockades, making farm life still more attractive to the clever country-bred boys and girls.

Already audible radio is rapidly changing our social order; those who may now listen to a great man or woman are numbered in the millions. Our President recently talked to practically the whole citizenship of the United States at the same time.

When to this audible radio we add visible radio, we may both hear and see great events; inaugural ceremonies, a football, polo, or baseball game; a regatta, Mardi-Gras, flower festival, or baby parade; and an entire opera in both action and music.

This we shall soon take up for completion, and with the utmost confidence, for dollars and brains can do most anything. Brains sometimes without the dollars, but never dollars without brains, without the know-how.

"But, Jenkins, when may we expect this wonderful buggy ride?"
"Why, just as soon as I get the benzine to make it go, I've got the buggy."

DISCUSSION

PROF. WALL: Are the results shown in half tone or silhouette? My reason for asking is that it was recently announced before the French Photographic Society that M. Belin had sent radio movies from Lyons, 300 or 400 miles away. The movement was said to be very slow and only silhouettes could be shown. By half tone I mean photographic half tone and not the dot pictures as used in illustrations.

MR. JENKINS: We can show either or both. Silhouettes are the easiest to send and are all that is possible on CW. To get half tones we are limited to a modulation set, although CW has many times the reach of the other. I think that some of you are aware that we have been sending half tone stills by radio for 6 or 7 years and are familiar with the system, and that to have radio movies means only increasing the speed of analysis. I mean photographic half tones.

MR. RICHARDSON: What difference does a change in the speed of action make?

MR. JENKINS: This invention is going slowly from crude to better results all the time. In the beginning when higher speeds were involved in visual radio we took all the advantage possible. We ran the machines as slowly as would give us results, say, twelve to fifteen pictures a second, when the machine runs slowly, a slow performance gives better results. The problem is not greatly different from film in many ways.

A DISSOLVING SHUTTER MECHANISM FOR MOTION PICTURE CAMERAS

BY D. L. MISTRY

REALIZING the importance of the dissolving shutter on professional cameras, I have devised the following simple types to be used on amateur cameras which have not been fitted with such devices primarily because of the added cost of manufacture.

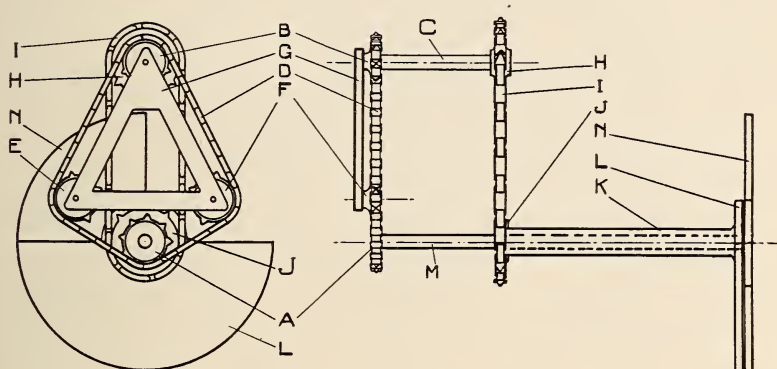


FIG. 1. Plan and elevation of shutter dissolving mechanism.

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|-------|-----------------------------|-----------------------------|
| A | Main shutter shaft sprocket | } same size
and
pitch |
| B | Counter shaft sprocket | |
| E & F | Idler sprockets | } same size
and pitch |
| C | Counter shaft | |
| D & I | Chains | |
| G | Sprocket frame | |
| K | Aux. shutter shaft | |
| L | Aux. shutter blade | |
| H | Counter shaft sprocket | } same size
and pitch |
| J | Aux. shutter shaft sprocket | |
| M | Main shutter shaft | |
| N | Main shutter blade | |

The operation of the shutter is that of slowly advancing an auxiliary shutter with respect to the main shutter, thus slowly closing or opening the open sector. This is done by linking a sprocket *A* Fig. 1 on the main shutter shaft with a sprocket *B* on a countershaft *C* by a chain *D* which also passes over idler sprockets *E* and *F*. The spindles of sprockets *E* and *F* are carried on a rigid frame which may

rotate about the countershaft *C*. Mounted on the countershaft *C* is a second sprocket *H* linked by a second chain *I* with a sprocket *J* on a tube *K* coaxial with the main shutter shaft and carrying the

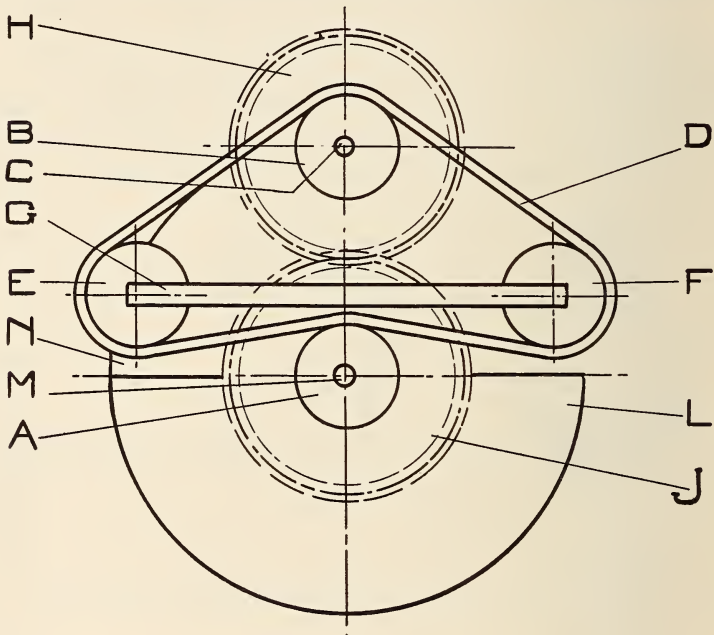


FIG. 2.

- | | | |
|---|-----------------------------|-----------|
| A | Main shutter shaft sprocket | same size |
| B | Counter shaft sprocket | and pitch |
| C | Counter shaft | |
| D | Chain | |
| E | Idler sprocket | " |
| F | Idler sprocket | " |
| G | Sprocket frame | |
| J | Aux. shutter shaft gear | same size |
| H | Counter shaft gear | and pitch |
| L | Aux. shutter blade | |
| M | Main shutter shaft | |
| N | Main shutter blade | |

auxiliary shutter *L*. The sprockets are of such sizes as to give the same speeds to the two shutters. The shutter combination is geared to the camera in timed relation.

The operation of the shutter is as follows: As long as the frame *G* has a fixed relation to sprocket *A* the shutter will have a constant

angle of aperture. If, however, the frame be moved in relation to the sprocket *A* the relative angular positions of sprockets *A* and *B* will be altered and accordingly the relative positions of the two shutters *L* and *N* changed, since shutter blade *N* is fixed in relation to sprocket *A*, and shutter blade *L* is fixed in relation to sprocket *B*. Thus for a fade-in the frame is moved gradually to the right, and to the left for a fade-out.

The mechanism can be varied in a number of ways according to the adaptation to the particular camera. For instance, as in Fig. 2, the sprockets *H* and *J*, of Fig. 1, may be replaced by gears in mesh and sprockets *A*, *B*, *E*, and *F*, linked by a chain as shown in Fig. 2. The aperture may be altered by moving the carriage *G* from the right to left. The hollow shaft may also be eliminated.

A similar device may also be applied to the feed and take-up sprockets of a projector to adjust the loops. It may also be applied to the shutter drive and used to adjust the timing of the shutter in order to remove "travel ghost" while the projector is in operation.

In conclusion, let me call the attention of the Society to the need of a compilation of the art of the industry in the form of an encyclopedia or an equivalent form giving a ready reference to all that has been accomplished from the beginning.

Hyper-sensitizing ciné film.—MM. Gibory, Bachelet & Berliet have used with marked success the following method of hyper-sensitizing film:

Pinachrome, 1:1000 alc. sol.	15 ccm.
Pinacyanol, 1:1000 alc. sol.	8 ccm.
Methyl alcohol	40 ccm.
Distilled water	1000 ccm.

The film was bathed, on silvered frames, for 3 minutes in the dark, then washed for 1 minute in running water, immersed in an 8 per cent solution of strong ammonia, again washed for 1 minute and dried on a drum. Development was effected with glycin after 2 minutes desensitizing with basic scarlet N. This method was found to more than double the speed of the film and it would keep 2 weeks. (La Cinémat. Franç.; Filmtechnik, 1927, 3, 148).

A NEW LIGHT SOURCE FOR MAZDA PROJECTION LAMPS

H. I. WOOD.*

LIKE so many of the good things of present day industry the light source described in this paper is the product of the work of a number of different investigators over a considerable period of years. The principle is not new, but it is only with increased knowledge and with improved materials of recent times that the present results have been possible.

From the beginning of the motion picture industry, the equipment manufacturers have been calling ever for "more light" and no sooner have the lamp manufacturers met any set requirements than the standard has been raised. We feel now that we are perhaps a lap ahead and consequently are glad to take this opportunity to present our achievement.

The standard construction of a coiled filament operating in an atmosphere of inert gas—the Mazda C lamp—is now universally known. By coiling the filament its effective length is brought down to about 10 or 15% of the straight wire length. This permits a much greater concentration of the light source. But there are limits beyond which it is not possible to go. There must be a definite minimum separation between the segments or there will be either arcing, or short circuiting, due to almost unavoidably slight warping or twisting. Also it has not been found commercially possible heretofore to produce a projection lamp of less than 100 watts in the 115 volt range and even this lamp requires our most skilled operators.

The lamp described below has allowed us to go a step further. Starting with the regular coiled filament it is again coiled, making what we have designated as the "coiled-coil" filament. This has made a further reduction in the effective length to about 25% of the coiled filament or to approximately 3% of the length of the straight wire. The resulting filament can thus be concentrated into a still smaller area. Actually as shown in Table 1. this area for 100 watts is reduced to less than half. There are, of course, definite limits to this new construction. The separation of the segments must be kept wide enough to prevent arcing—possibly somewhat wider than with the coiled filament, for, with fewer segments, the

* Incandescent Lamp Department of the General Electric Company.

maximum voltage across any two adjacent points is higher and the arcing tendency more pronounced. Further, as the diameter of the coil becomes greater, the front portions block off part of the light from the rear portions and prevent its getting through to the condenser.

Some advantages of this construction are:

1. A greater concentration of light source. This can be utilized by either retaining the wattage and lumens and putting them into a smaller area or by retaining the area and putting into it more wattage and luminous area;

2. The possibility of a commercial projection lamp of 50 watts in the 115 volt range;

3. A lamp in the 115 volt range with approximately the same light source area that is now standard in a lower voltage.

In connection with the last two points, attention is called to the fact that it has been customary in some instances to use a low voltage lamp with series resistance. This means, on one hand, a loss of energy to the user, and on the other, the need in the equipment of an additional piece of apparatus, increasing the cost and sales price. While neither of these items is of great importance for the smallest sizes, it becomes of some moment in lamps of 200 watts or over. Another item not to be overlooked is that with a low volt lamp and regulating resistance it is not easy to adapt this combination to all conditions of voltage found in various central stations (unless an ammeter is employed). The lamp may thus be operating above its normal voltage and so give the user short life, or it may be under voltage and give poor screen illumination. With the 115 volt type, a lamp of the correct voltage can ordinarily be used and both difficulties avoided. In order to prevent any misunderstanding it should be noted that in changing from a 50 volt to a 115 volt lamp of the same wattage, there is some loss in total lamp lumens as the 115 volt filament is of smaller wire size and so must be operated at somewhat lower temperature.

Before presenting figures for screen tests on the various wattages it may be of interest to show some of the steps used in the manufacture of the coiled-coil filament. These are shown for a 200 watt 115 volt lamp in Fig. 1. *A* is the regular coiled filament with the mandrel on which it was wound still intact. *B* shows the next step where the coil *A* is being wound onto the second mandrel. *C* is the coiled-coil formed into shape, after which it is heat-treated and the

mandrel wires dissolved. It is shown in the finished form ready to go into the lamp at *D*. *E* is the regular coiled filament of the same wattage and is shown to compare the relative dimensions of the two types of filament. Fig. 2 shows the finished lamp.

As shown in Figs. 1 and 2, the coiled-coil filament in the 115 volt range is made with 3 segments. This is partly because of the point mentioned earlier, that with the greater concentration the arcing tendency is greater. With the 3 segments the points of maximum voltage are on the diagonal of the filament, which is the greatest distance possible with a given concentration.

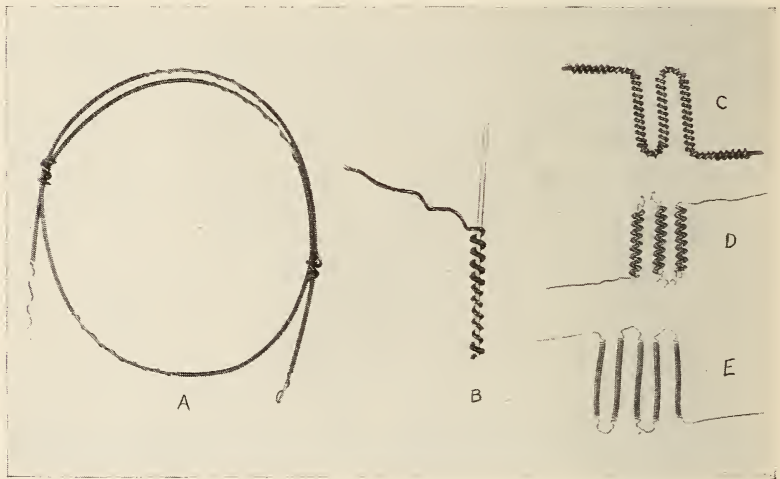


FIG. 1

Table No. 1 summarizes figures obtained in our Engineering Dept. with several sizes of the coiled-coil filament and, for comparison, coiled filament lamps of the same wattage. The optical system used for these tests consisted of a standard 16 millimeter aperture, a three element condenser, an objective of about F 2.25 speed, and a mirror, all accurately set on an optical bar. This system was chosen as it is similar to some in commercial use.

The comparison is made on the basis of equal watts and equal life. It may be well to point out that while the customer, under service conditions, would not secure the same results as shown in the table the relative values would be similar. There might even be,

in some cases, a greater gain by the use of the coiled-coil filament lamp. For instance, if an optical system was designed to make use of the smaller source area, an additional gain might reasonably be expected.

Table 1. *Relative Screen Illuminations and Source Data for Coiled-Coil and Coiled Filament Lamps.*

Lamp Rating		Light Source		Screen Lumens				% Increase	
		Area-Sq. mm.	C.C. Fil.	C. Fil.	C. Fil.	C. Fil.	C.C. over C.	C.C. over C.	
Watts	Volts	C.C.	C	Bare	Mirror	Bare	Mirror	Bare	Mirror
50	115	18	—	9	16	—	—	—	—
100	115	25	56	23	35	14.5	23	59	52
200	115	49	81	43	66	32	55	34	20
200	50	33	43	46	70	48	75	-4	-5



FIG. 2

On the second line in Table 1. is given the data for the 100 watt 115 volt lamp. As shown in columns 3 and 4 the light source area of the C.C. (coiled-coil) filament has been reduced to less than half that of the C (coiled) filament. The screen lumens are given in columns 5 to 8 and the percentage increase with the coiled-coil filament in the last two columns. This increase is approximately 50%.

By "Bare" is meant the light projected with the mirror removed, but the rest of the setting identical.

On line 3 is the data for the 200 watt, 115 volt lamp. This shows a smaller reduction for the light source area than with the 100 watt and correspondingly, a smaller increase for screen lumens, though a marked gain.

The last line—200 watt, 50 watt—shows slightly lower screen lumens with the coiled-coil filament.

Tests (not shown) have been made on lamps of higher wattage but they have not indicated, with the 16 mm. aperture, any marked increase over the 200 watt lamp.

Other forms of projectors, using larger than 16 mm. apertures and projectors such as spot lights, search lights, stereopticons, etc. have not yet been tested. Knowing the effect of smaller light sources on such systems, it seems reasonable to expect marked advantages when higher wattage lamps have been developed.

To summarize: This new light source has permitted us to offer a 50 watt, 115 volt, projection lamp; it will give an increased screen illumination of about 50% for the 100 watt lamp, and 20% for the 200 watt lamp. It does not yet offer advantages for lamps of higher wattage, or of low voltage when used with a 16 mm. aperture. For equipment using larger apertures, and for projectors like the spot light it seems reasonable to expect a material improvement from higher wattage lamps, when they have been developed.

Another Hyper-sensitizing Process.—Two Berlines (Germany) investigators, Moise Safra and Reimar Kuntze, have it is announced, made a wonderful discovery by means of which an interior set may be taken by the light of a single incandescent lamp. For outdoor work it enables one to take dark woodland scenes, late evening and night effects. This wonderful result is attained by passing the film through a certain chemical bath. The only disadvantage is that the film must be used within a month; "but it is hoped to overcome this defect as preliminary experiments have proved this to be possible." According to the inventors excellent results have been secured of a group illuminated by red light only. (*Le Cinéopse*, 1927, 9, 341).

ILLUSIONS IN CINEMATOGRAPHY

BY FRED WALLER*

THE field covered by this title is so large, that I have selected for this paper samples of only four of the many lines along which this work is pursued at the East Coast Studios of Famous Players-Lasky Corporation:

First, the Storm Episode from the Gloria Swanson picture, "The Untamed Lady," which is a reproduction of a natural scene in miniature; second, the episode showing magazine illustrations coming to life, from "The American Venus," directed by Frank Tuttle, which is really the reverse of a miniature shot; third, the delirium scene from the Thomas Meighan picture, "Blind Alleys," which is the production of a psychological effect; fourth, the coach going through the gates of Heaven, from "A Kiss for Cinderella," directed by Herbert Brenon, producing a purely imaginative scene.

These four scenes have been selected not only for the different effects produced, but also for the different technical, artistic and dramatic problems which were involved in their production.

The most important part in the production of an illusion is the planning of the scenes and the determining of the particular methods to be used. Unfortunately, it would consume too much time to recite this in full. I will, however, give you an outline of this part, as well as the mechanical work done.

The Storm at Sea.

The problem here was to produce an effective, realistic scene of a storm at sea to cut in with the action made of the real people in the studio, and to do this in as small a scale as possible.

It was desired in the picture to show the boat returning home after the storm in a disabled condition and some prominent portion had to be destroyed. It was decided that the fore-mast should be struck by lightning and this had the additional advantage that the lightning flashes illuminated the scene and showed the wind gusts more clearly.

To determine the scale of the model, some simple experiments were made, and it was decided that 5/8 inch to the foot would give us a good long shot effect of breaking waves. This scale required a tank

* Famous Players-Lasky Corporation.

40×60×5 feet deep. Two models were constructed and used in this same tank, one in 5/8 inch scale for the long shots and a partly-finished one in 1 inch scale for the close-ups. On this 1 inch scale model only the bow of the boat and the stern propellers were ever shown in the picture. The over-all length was 15 feet.

Previous experience had shown that towing boats by an invisible wire, or running them on a track, gave an unnatural movement and therefore the 5/8 inch model, which was actually 8 feet long, was equipped with two small high-speed motors actually driving submerged propellers, and connected through a rubber-covered electric cable which the boat towed, to a control board at the end of the tank. The connections made through this cable also lighted the lights on the boat and controlled a solenoid which operated release triggers on the six shrouds supporting the front mast and also a dowel pin which was inserted in a break previously made in the mast. This allowed us at will to let the mast blow away and fall overboard, and to steer and control the speed of the boat without ever touching it.

This little model, under its own power, actually pushed its way up against the three-foot waves and the wind from four airplane propellers, without any assistance.

Most miniature shots can be detected by the unnatural appearance of the water. Therefore, the next problem was to produce the correct type of breaking wave. This was solved by designing four special wave machines which were used at the right-hand side of the tank. Their construction was of solid wood and they each weighed about a ton. They were formed so as to present a 4 foot surface at a 45° angle to the surface of the water, so that when they were raised, the water would rush under them, and when they were lowered against this inrush, they would move the water faster at the surface than at the bottom of their stroke. These heavy wedges were actuated by long levers and as all of the scenes took less than a day to photograph, it was cheaper to use man-power than to install mechanical means for doing it. It may be of passing interest to note that it took twenty-four men to produce the waves.

This effect, accompanied by the wind on the surface, produced by the airplane propellers, gave a fine, tumbling wave. Still further invention was necessary, however, for if this wave was allowed to strike the flat wall on the far side of the tank, part of it would rebound and spoil the effect of an open sea. Consequently, a wave absorber was built, in the form of layers of heavy wire mesh supported on

timber bracing and covered with fine wire mesh, twelve layers being put about 4 inches apart and extending to the bottom of the tank running the entire length of the tank, which was 60 feet. The action of this was to cause so much resistance to the waves, that by the time they passed through these layers and back again, there was no real disturbing effect.

Even a photographic backing presented a slight problem, as it had to be waterproof and of such a texture as not to show where the surface had wet it, and be built solid enough so that the waves would not tear it loose. This was met by a gray waterproof backing, 20×40 feet, painted on heavy canvas with a paint which was a combination of oil and water pigment. This backing extended to the bottom of the tank.

To give a satisfactory night effect and still show the rain and gusts of wind, only a small amount of front light was used. Most of the lighting was back light on the rain with only part of this striking the boat.

The dimmer lightning flashes were produced by shorting an electrical circuit, which is the standard studio practice.

The more brilliant flashes were put in by staining frames of the negatives with an anilin dye of a non-actinic color. The forks of lightning were put in on the negative with an extremely fine pen and an opaque ink, timing the progression and skipping frames to give a realistic effect.

The production of a good rain effect necessitated the combination of extremely fine needle sprays directed in the path of the airplane propellers and clouds of nebulized Nujol to represent the blowing spray which accompanies every gale.

The cameras were set at a very low level so as to give height to the boat and waves. At the end of the tank which was somewhat protected from the waves, pieces of plate glass were inserted to photograph through. A cranking speed varying somewhat with the length of the shot and running from eight to twelve times normal, i. e., from 128 to 192 pictures per second was decided upon. This gave the three-foot waves the necessary timing of thirty-foot ones, while the mast appeared to fall slowly as a large mast really would fall.

Magazine Illustrations Coming to Life.

The scene the director desired was bathing girls illustrated in a magazine becoming real and stepping out and performing on Ford

Sterling's desk as he is admiring them. He orders them back as his puritanical wife appears on the scene.

The most important thing here was realism. Anything which the audience might detect as being artificial would greatly detract from the episode as a whole. It was decided that a complete illusion could be produced by cutting in close-ups of Ford Sterling and using four different methods of showing the book.

To do this, a desk top was built twelve times as large as the real desk appeared in the original scenes in the picture. The penholder, desk pad, letters, etc., were all built on the same scale.

The camera was placed in the same relative position as a man's eye would be. This figured out to be about 20 feet from the back of the desk, and 16 feet above the writing pad. One of the problems was to get enough light for a full exposure and still have it possible for the girls to act normally without being blinded by the light. Fortunately, we were aided in this by the fact that a small figure should move quicker than a large one, therefore a cranking speed of about eight to ten pictures per second was used for most of the shots. The reason for the light difficulty was the extremely small aperture necessitated by the depth of the photographic field, as the man's hand which appeared in the picture was only 3 feet from the camera, and the small figure on the desk was over 20 feet from the camera.

The normal-size magazine was made out of photographs printed on matte-surfaced paper, the photographs being still reproductions of the large pages with the girls standing in them in the same place as they appeared when first seen in the film.

The methods used in photographing the action of the girls and the magazine pages so that it would not be obvious to the audience as to how it was done were:

First where the hand opens the book and the girl steps down from the illustration, only half of the magazine was built in large scale, three pages of a small magazine being mounted on the glass 3 feet from the camera in registration with the enlarged page which the girl was standing against. As the hand opened these pages, the enlarged page with the girl in front of it was disclosed, and the registration and lighting made it look like one complete book.

Second, the next girl steps out from behind a page, which is made of quarter-inch beaver board, purposely made curly, covered with muslin on both sides, and painted in scale to look like a page of a magazine, the left-hand side still being the normal size book near the

camera. This same method was used for the page which was opened by the first girl, disclosing the third one standing motionless.

Third, the page which was apparently kicked open by the third girl was a normal-size magazine page, which was really 17 feet away from her. This page was a photograph of the background on which the second girl stood, placed beside the left-hand side of the book on the glass close to the camera. Here a little ingenuity was necessary. This page must be opened quickly, bulging out in the center as though pushed by a foot, but without any visible means of moving it. As this page was only 3 feet from the camera, the finest thread or wire possible would have shown, so a jet of compressed air was used and proved very successful. With a little rehearsing and timing, the girl carried out a kicking gesture simultaneously with the blowing over of the magazine page, thus making a very realistic effect.

Fourth, in order to give the girls more scope for action and to prevent the audience from realizing that there might have been small pages used in this set-up, the left-hand side of the book was built in large scale and the glass removed.

Naturally, these different methods could not have been combined if all of this action had been played in one continuous scene. However, an episode like this is not only more convincing but much more entertaining if you cut back to the principals in the picture and make them a more intimate part of the episode.

The end of the episode where the girls are ordered back by a gesture of the large hands into the book and one of them gets caught, was done in combination with the small book on the glass, as in the first method, but considerable care in timing the action of the girl was necessary to make it look as though the page had actually hit her.

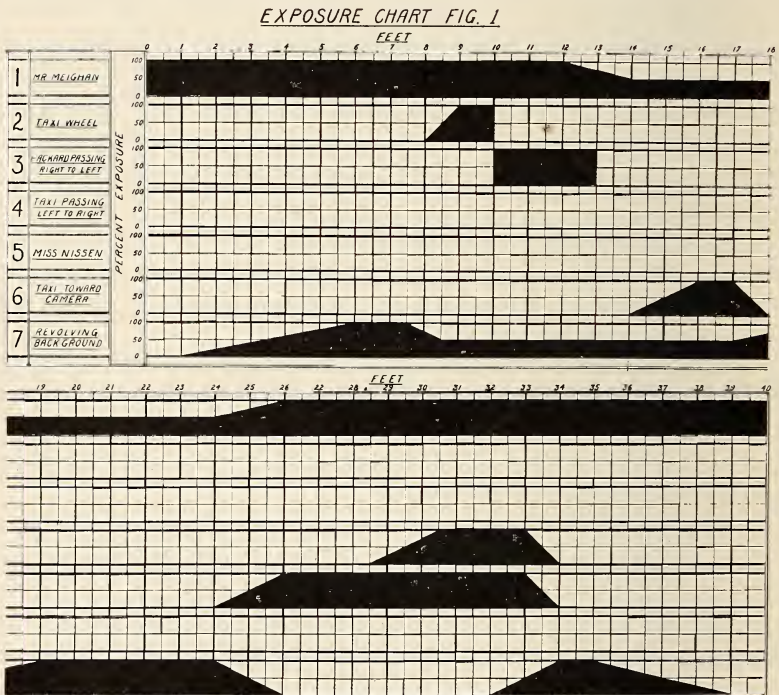
The Delirium Scene.

This episode was to depict what would take place in a delirious man's mind, who had been struck by an automobile and separated by this accident from his bride.

The place at which this action occurred was Broadway and 44th Street, and it seemed logical that the man would confuse the rushing automobiles and the swirl of lights as he became dizzy from the impact. His wife appeared to him through the confusion, and finally restored his composure.

A sequence like this could be done directly in the camera running the film through seven times and with mats covering up all of the

different sections that the additional exposure should not appear on. However, the length of time necessary to work this out on the stage and the chance of error was so great that it was decided to do this entirely by making a duplicate negative on a projection printer especially designed to do trick work. Therefore, the scene of Mr. Meighan in bed, which was the key negative for the series, was made in the studio in the normal way, and this required no special treatment



except space around the figure in which to place the additional action. Then a negative was made at night on Broadway, with a camera mounted close to the ground on a revolving mount, so that the effect of a whirling mass of lights was produced, and several scenes of automobiles taken from different angles and with different action, were made; also a scene of his wife made against black velvet.

Prints of all these scenes were made and were cut so as to secure the best parts of each. Then a chart (See Figure 1) was made showing the different positions in which each of these was to appear over the key negative with varying lengths of fade-ins and outs, and varying exposures.

On the projection printer, a test print showing several different densities was made from each negative and from this the correct exposure for the different effects was selected. These tests, of course, were developed simultaneously in a developer of a given strength and at a given temperature. Scenes which were not to appear in the same part of the finished dupe were combined in the projection printer on the positive. This reduced the number of times that the finished dupe would have to be exposed.

The next step was to make a duplicate negative from the key scene of Mr. Meighan varying this exposure as per our chart, and on to this exposed negative before development, negative impressions from the other four positives were successively exposed each of which contained one to three scenes.

This method may sound very intricate but the great advantage is that the time of a stage unit is not taken up to perform this very technical job. Only one or two men are needed to work on laying it out and printing it, in a little separate laboratory. Not the least advantage is that if the position, timing or exposure is not satisfactory, it is simply necessary to change the chart and make a new print and duplicate negative, as none of the individual scenes has to be remade. The most important point of all, however, is the perfection in timing and selection made possible by this method.

For these seven scenes, about four takes each were made and the best ones selected from a print. Then the best parts of the selected ones were cut and joined together in the regular manner. This film was run many times to complete the cutting and alter the timing. From this the aforementioned chart was made.

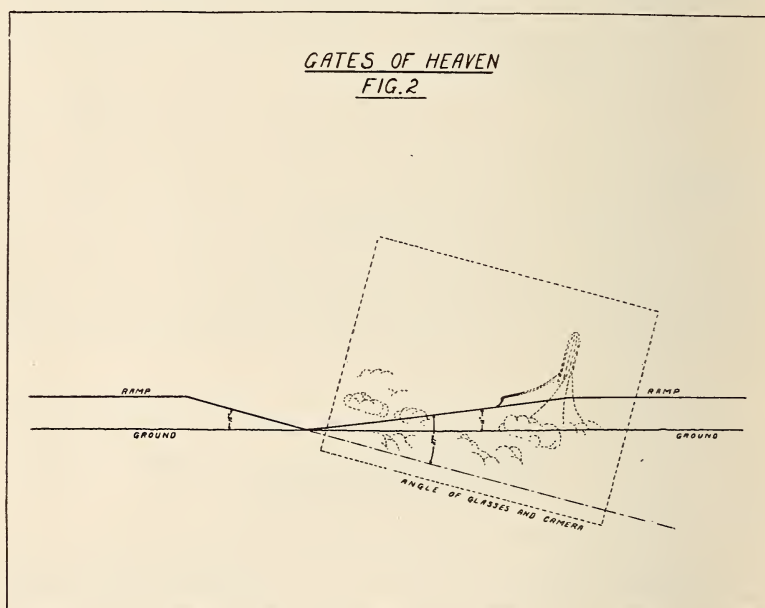
To have secured this degree of perfection in the camera would have been very nearly impossible. Consider mathematically just the selection of scenes: the chances would be the 7th power of 4 against 1 for getting all this perfection in one take.

It is, of course, necessary that this type of work be done with extreme accuracy. Great attention should be paid not only to precision in the machinery but to cleanliness and care in handling the negatives and to uniformity of quality in laboratory work, so that the finished result will be of good standard quality.

The chart, shown as Fig. 1, will give you an idea of the method whereby the different scenes were used.

The Coach Going Through The Gates of Heaven.

Mr. Brenon desired to depict in this scene the idea which a little English slavey would have of a trip through the gates of Heaven in a coach drawn by four white horses. Sketches and wash drawings were submitted to Mr. Brenon suggesting different final effects to be obtained, without regard as to how they were to be done. Upon his selection, we proceeded to figure out the most economical and efficient method consistent with quality and in this instance, great speed, because due to some other circumstances, this had been postponed up to within a short time of the release date for this picture.

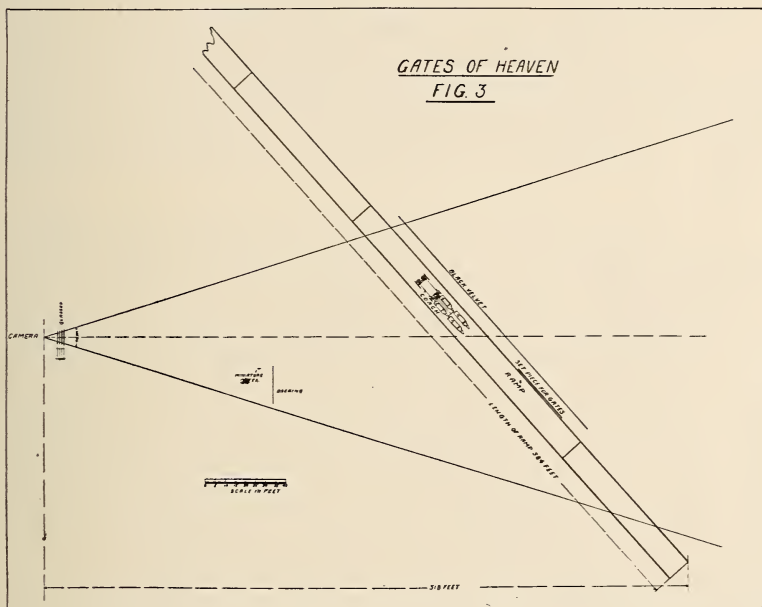


For a great portion of this work, multiple exposure would have been possible but this would have meant delay in screening the final scene and a chance of error, and at this time our projection printer was not finished. Therefore, it was decided to use several planes of action combined in a single exposure.

The first practical consideration was how steep a hill could four horses draw up a coach without seeming to labor too much. It was found that this angle was not nearly steep enough to give the desired effect, so a ramp or runway was built on which the horses could get a

running start downhill before they entered the picture and then proceed up an incline at a 12° angle. As an angle of 27° was needed in the picture, the camera was tilted the necessary additional amount. In Fig. 2, the angles of the ramp and camera are shown. Fig. 3 is a ground plan of the set, which was in a football field hired for the purpose.

Starting from the camera the different photographic planes which were brought into registration to make this scene were as follows:



Three moving glasses with clouds painted on them, the glass nearest the camera moving the fastest, the next one at a middle speed and the third one the slowest, so as to give movement perspective.

The fourth plane was a fixed glass, on which was painted the arch in which the gates swing, the pathway through the clouds and the temple beyond the gates. In the painting on this glass there was an opening left for the gates and the lower far side of the archway. Also an open space for the coach and horses to mount through.

The fifth plane was a pair of miniature gates mounted in position to register with the fourth glass and arranged to swing open with hidden levers.

The sixth plane was a backing behind these gates to correspond with the cloud effect on the fourth glass.

The seventh plane was the actual coach and horses running on the blackened surface of the ramp, backed by black velvet drops 20 feet high and totally 200 feet long.

The eighth and last plane was a small built section of the portals, built just high enough to cover the height of the coach, and made to exactly match with the balance of the portals which was painted on the fourth glass.

For the desired effect, it was necessary to light these different planes of action entirely by artificial light and therefore these scenes were done at night. The front glasses were lighted by arc and nitrogen lamps; the gates with their backing by G. E. lamps, the coach and portals by still more G. E.'s, about fourteen in all of these being used for this set.

The nicety of light matching that was necessary can easily be imagined. However, we had the good fortune to light, test and photograph this entire scene in one night.

The foregoing will give you a fair idea of the methods used in making these scenes. Of course, the chief consideration is that the scene be of dramatic value not in itself but as it will be used in the finished picture, in conjunction with the other scenes with which it completes an episode. Frequently, the best part of a miniature shot considered as an individual scene, is cut out because the dramatic action may be strengthened by the use of other scenes and all of this must be considered in the first planning of a trick shot. In fact, it is in this planning that a breadth of experience and knowledge counts. When it is once planned, all that is needed is care and artistry. Even when these scenes are finished and out of the hands of the man who makes them, they can be considerably enhanced in value by correct cutting and editing. Therefore, as far as possible, it is the miniature man's job to see that his work fits so perfectly the mood of the scene that it will be used as originally planned in the finished picture.

DISCUSSION

MR. THEISS: Is the half-exposure over the entire surface of the film or is it a split screen?

MR. WALLER: That is over the whole thing; there was no split screen on any of that.

DR. HICKMAN: What is the idea of making the horses go up hill at all if the camera can be tilted?

MR. WALLER: That is a good question. There was, however, a good reason for it. We tried the horses on the level but it did not give the same effect because they showed no strain; the position of the horses' bodies and the people on the coach made it look as though the picture had merely been tilted. We could steal on that by giving them a slight tilt. The horses strained on the traces a little and the people leaned forward a little.

MR. JENKINS: Were the portals built on an angle?

MR. WALLER: This much of the portals was not built; this (indicating) was. This was built at an angle to be perpendicular in the camera and all the glasses were plotted at this angle.

Photographing Model Scenery.—Writers in the lay press and in journals of the tit-bit type delight in giving away what they believe to be the secrets of cinematography, and we often read of how railway accidents and other exciting events are photographed from well-made models. The idea, however, is by no means so new as many would have us believe it to be. In the 'sixties' of last century, when the stereoscopic craze was at its zenith, many interior views were obtained from models. Many of the once famous Ferrier and Soulier stereoscopic interiors were made from models, and their successors, Levy et ses Fils, often built up a small model in order to make a stereoscopic negative of it when the picturing of the actual scene was impossible, and the work was so well done that few, if any, who purchased the pictures were aware of the deception. The models were, of course, made mainly from monocular photographs in order to picture the details as accurately as possible. A "B. J." correspondent, who a generation or so ago worked in the famous stereoscopic studios at Grenelle, a suburb of Paris, assures us that the models were most realistic, much time and thought being expended in their production, the firm employing an expert scenic artist and model maker, one of whose masterpieces was an interior of the Coenaculum (Tomb of David), which may be in some of the collections treasured by admirers of the stereoscope. (*Brit. J. Phot.* 1927, 74, 234).

SOME FAULTS DEMANDING ATTENTION

F. H. RICHARDSON*

SINCE the image upon the screen of the theater represents and is the finished product of the motion picture industry displayed for purchase by the amusement buying public, and since this is the only goods of any sort which the industry has for sale, it seems eminently fitting and proper that we spend a few moments in consideration of the faults most commonly found therein, and in examining into the possibilities for at least their partial correction, if their complete elimination is deemed not practicable.

That grave faults not only do exist, but also are very common, is apparent to those who view screen images with discriminating and understanding eyes. No one in the industry, I believe, seriously questions either their presence, or the fact that they operate to detract from the amusement value, and therefore from the sales value of the motion picture as represented by the box office income.

If we concede the truth of the foregoing, then we cannot but agree that the reduction or elimination of screen image faults is an extremely important matter, no matter from what angle it be viewed, including the financial one.

It is not the purpose of this paper to direct your attention to more than a few of the more serious faults. To consider them all in detail would serve no good purpose, since many of them are due directly to errors in projection procedure, few of which have any right place before this body.

At the very head of the list of faults stands graininess of the screen image, which exists in widely varying amounts, from that barely sufficient to be visible, to an amount which has the general appearance of snow swirling and tumbling about in the air. Graininess is responsible for more real damage to beauty of the screen image than any other fault which can be named.

To be able to fully grasp the evil effects of graininess it is necessary that one view scenes in which it is present, followed immediately by scenes in which it is not present, and through the kindly co-operation of the Universal Film Mfg. Co. which consented to prepare sufficient film for a demonstration before this body, I am

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able to present to you a convincing illustration of the effect of graininess. *Demonstration.*

The difference between film free from graininess and film containing it is, I think you will all agree, a bit startling. Graininess has the effect of changing the blacks to a more or less pronounced gray. The more delicate shadings in photography are either partly or wholly lost, because of the fact that the whites are no longer pure white, but have sufficient discoloration and density to very closely match the lighter photographic shades.

One very bad effect of graininess is its tendency to blur the lines in the photograph, and thus set up the effect of lack of definition. In fact the effect of graininess is bad in every way.

I am not a laboratory man and do not know the cause or causes of graininess. I have been told that much of it is caused by the duping of negatives in order to speed up positive printing. I have also been told this is not true. I have been informed that improper exposure of the negative in photography is responsible for much graininess. I have also been told this is not the fact. I am not a laboratory man, I repeat, and do not know what is the cause, but the effect I understand very well indeed, and it is distinctly bad.

Interesting papers on the subject of graininess have been read before this Society in the past. One of them was by Arthur C. Hardy and Loyd A. Jones. It appears in the TRANSACTIONS (No. 14) of the Boston meeting held in the year 1922.

Gentlemen, may I direct your attention to the fact that this paper appeared in the year 1922, yet five years later nothing effective has been accomplished in the reduction of graininess, notwithstanding the fact that it is now and always has been working literally tremendous damage in that it is rendering the placing of a perfect screen image before the public impossible.

Some who should be in position to know assert that graininess is due to the use of poor or unsuitable emulsion. What degree of correctness, if any, this statement carries I do not know. The cause and remedy is a matter for the attention of our laboratory engineers.

In closing this matter I will say that graininess is present at least in some visible degree in at least some of the scenes of almost every production, and in all or practically all scenes of a very great number of them.

It is idle to say that graininess cannot be avoided. I venture the assertion that if all producers set a date some distance in the future of next year, beyond which time they would accept no positive print containing visible graininess, from that time forward, though production costs might be somewhat higher, there would be no more visible graininess.

Another very serious and common fault is the lack of proper contrast values in the various portions of the screen image. Blacks are not blacks, but a more or less "dirty" gray. Blacks must be perfectly opaque and the various shadings of the photograph must have their true values if the highest possible value in beauty is to be attained in the screen image.

There can be no possible argument on this point, yet it is a fact that we find an astonishing percentage of scenes in which there is no sharp, clear-cut values in photographic shadings, or in which the shadings have not their true values.

This effect is because those portions of the film photograph which are presumed to produce black on the screen are not opaque. They "leak" light, hence the supposed-to-be black appears as a more or less pronounced gray on the screen. The contrast value is, of course, reduced, and if the light leakage be considerable, it is very greatly reduced.

By the same process the various shadings lose their true values. They pass more light than they should, hence do not carry their correct proportions of contrast in the film image.

The net result of this is two fold. First, as we have pointed out, there is no true contrast values, and the picture looks "flat." Second, there is an apparent damage to definition, though of course that is merely an illusion set up by lack of correct contrast and the effect of the light leakage at the dividing lines between the whites and supposed-to-be blacks.

Perhaps I have not described this condition as clearly as I might, but believe you have all viewed the effect so many, many times that you will understand fully just what I have in mind. However, again through the kindly co-operation of the Universal Film Mfg. Co., I am able to demonstrate the actual effect of the fault by contrasting it with an image which does not contain it. *Demonstration.*

The fault which perhaps stands third in ability to inflict damage to the screen image by detracting from its beauty is distortion, usually due to locating the projection room so high above the screen

that a projection angle varying from considerable to very, very much in excess of the maximum projection angle approved by this body is produced.

This fault is so very common and its evil effects so well understood, that there seems small need to discuss it. May I, however, venture to suggest the thought that in the past we, as a body, have made but very little effort to secure the actual adoption of the standards we have set up.

A maximum projection angle of 12 degrees was approved by this body several years ago. Can we point to anything this Society itself has done to have this standard, or recommended practice adopted and put into actual general use?

It seems to me we cannot reasonably expect to set up standards, or put forward recommendations for practice which are opposed to present methods, no matter how much in error present practice may be, and hope or expect them to be adopted unless we ourselves make at least a reasonable effort to have them recognized and adopted.

I would most respectfully suggest that when it is found that the industry is following a wrong and injurious practice, such as, for example, projection angles which produce heavy distortion of the screen image, and this Society, after due deliberation decides just what practice ought to be substituted therefor, and sets up that finding as a standard or as a recommended practice, it should go further and use every means available to it to secure the general adoption of the thing it has created.

It would seem to me that this is of importance fully equal with that of the setting up of the standard or recommended practice itself, and that much might be done along these lines without imposing any undue hardship either upon the Society as a body, or upon its individual members.

For example: Every one conversant with the facts knows that distortion of the screen image works to the detriment of the beauty of the picture, and hence operates at least to some extent to reduce box office income in theaters where it is present in objectionable degree.

Exhibitors object to locating the projection room so that the projectors will be opposite the screen center, or nearly so, because of the fact that as theaters usually are now built, it would occupy space which might be used for other purposes, usually seating. The tendency is to place it way-back and high up, because up there space is least valuable of any in the entire theater.

Exhibitors do not as yet, save for notable exceptions, realize that the resultant damage to the beauty of the screen image set up by a heavy projection angle far more than counterbalances the presumed gain, because anything which detracts from the beauty of the picture works automatically and continuously against the box office. They overlook the fact that the gain in beauty of the undistorted picture as against the heavily distorted one, will operate to make all the remaining seats a bit more saleable, and that thus the loss of even a relatively few of the most valuable seats will be even more than compensated for.

Surely it would be entirely feasible for this body to have a carefully selected committee appear before both the exhibitor's and architect's organization, either in person or by written argument, and explain to them these matters in detail, urging that the standards and recommended practices of this body has set up be respected.

Gentlemen, I most respectfully suggest that in future when any standard or recommended practice is set up by this body, in connection with the adoption of which by the industry it seems expedient to appoint such a committee or committees, that they be appointed by our President.

I further suggest that a committee of suitable number, at the discretion of our President, be now appointed by him and instructed to appear before both the exhibitor's and architect's next convention in person if practicable, or if not then by written argument, and advise those distinguished bodies of the recommended practice this body has set up in the matter of projection angles, and the benefits to be derived from its general adoption.

In closing I might say that if such a committee is appointed the fact should be stressed before the architect's body that in the past the theater has been planned with the projection room considered rather in the light of an unimportant necessary nuisance, instead of planning the room from whence the thing the theater will have for sale being planned first, and the theater built around it.

True that may sound revolutionary, and even to some of you a bit absurd, but when we consider that a properly planned, properly located projection room is the only one from whence the screen image of highest possible sale value will or can reach the screen, we see that while it may be revolutionary insofar as has to do with the general present practice, it is in no sense absurd.

GRAININESS OF MOTION PICTURE FILM

J. I. CRABTREE*

WHEN a motion picture is viewed at a relatively short distance from the screen the various tones of the image are seen to consist of an agglomeration of small particles which appear to be in a state of boiling or scintillation. This lack of homogeneity of the tones of the picture is known as graininess, and for a given image is more apparent the greater the degree of enlargement and the shorter the distance of the observer from the screen.

The non-homogeneity of the image is due to the fact that a photographic emulsion is composed of small grains of silver halide which on development are changed to grains of metallic silver (see Fig. 1). During manufacture the individual grains in the emulsion tend to congregate in clusters and the silver grains which are visible on the screen consist of such developed clusters. The individual grains of even the coarsest grained emulsions are too small to be visible on the screen.

The apparent boiling effect is due to slight differences in position of the grain clusters as the single frame pictures are projected in rapid succession.

The word graininess is applied both to an undeveloped emulsion and the developed image. An emulsion may have inherent graininess due to the relatively large size of the grains and grain clusters, but the effect of this is only manifest in the developed image. Also, since the screen image is obtained by projection of a positive image which is usually prepared from a fine grained emulsion, it is of interest to study the extent to which the graininess of the negative image is recorded by the positive.

Previous to the investigations of Jones and Deisch¹ and Jones and Hardy,² little or no information was available regarding the factors which controlled the graininess of a developed image produced from a given emulsion. Motion picture workers were aware that different scenes from the same roll of film often showed varying degrees of graininess for no apparent reason. It is now possible to explain why this occurs and to indicate some of the conditions which tend to reduce graininess to a minimum.

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Factors Affecting Graininess During Exposure and Development.

In their investigations Jones and Hardy² measured the graininess of areas of uniform density obtained by varying the exposure and processing conditions. Their experiments were made by viewing a stationary image, and in most cases the author has confirmed their findings by preparing continuous lengths of motion picture film under practical working conditions and viewing the results on the screen.

It has been found that graininess is governed by the following factors.

1. The density of the silver deposit.

Under any given conditions and with all emulsions the graininess of a silver deposit increases as the density increases up to a maximum at a density of about 0.3 and beyond this graininess decreases. This is as might be expected since a density of 0.3 transmits 50% of the incident light. If a series of parallel lines are ruled on a strip of film, on looking through the film the lines can be seen at the greatest distance when the width of the lines is equal to the space between. From this it is obvious that the various tones in the screen picture will exhibit varying degrees of graininess according to their density. Graininess is always most visible in the lighter tones such as the face and in a uniform area of relatively low density. It is possible therefore to diminish graininess by avoiding large uniform areas whenever possible and when arranging a set by choosing backgrounds which will not render as densities around 0.3 in the final print. This however, is not a practical solution of the problem.

2. The nature of the emulsion.

In general, graininess tends to increase with the speed of the emulsion used but this is not an invariable rule because the inherent graininess of present day high speed emulsions is gradually being diminished by manufacturers without loss of speed. A perfectly grainless medium, however, whose sensitivity to light is of the same order as the present negative motion picture film has still to be made.

There are many occasions when an extremely fine grained material such as positive motion picture film can be used successfully for making negatives such as slide film negatives.³ Owing to the shorter latitude of this film in comparison with negative motion

picture film, the exposure must be more critical and a soft-working developer is necessary to avoid excessive contrast.

3. *The exposure.*

The experiments of Jones and Hardy² indicated that for a given subject and a constant degree of development of both negative and positive, the graininess of the positive increased as the camera exposure of the negative was increased. However, projection tests with matched positive prints made from negatives exposed on the same subject at $f/11$ and $f/3.5$ and developed for the same time, showed little or no difference in graininess of the prints.

The effect of exposure is dealt with at further length below.

4. *The time which elapses between exposure and development.*

If negative motion picture film with nitrate base is stored after exposure at relatively high temperatures (80°F or higher) in the presence of moisture, there is a tendency for the latent image to fade, that is, after development the density of the various tones will be less than if the film was developed immediately after exposure.⁴

Experience has shown that negatives returned for development by explorers invariably show excessive graininess whenever any considerable degree of fading of the latent image has occurred. The precise reason for this has not been investigated.

It is advisable therefore to develop film as soon as possible after exposure, but if this is not practical the access of moist air to the film should be prevented because little or no fading occurs even at high temperatures in the absence of moisture. Precautions for handling film after exposure in order to prevent fading in the latent image have been published by the author.⁴

5. *The nature of the developer.*

a. The composition of the developing solution. Jones and Hardy² observed that little difference in graininess was produced by the developing solutions in common use. Repeated projection tests have shown that for all practical purposes this observation is true. J. G. Capstaff of this laboratory has recently found, however, that a developer with a high sulphite and low alkali content gives negatives of negligible graininess in comparison with that of negatives developed in the commonly used developers. The formula of this developer is

given later. Although this developer contains elon and hydroquinone as the reducing agents, other developing agents may be substituted without affecting its ability to produce fine-grained deposits. The borax merely functions as a weak alkali.

The ability of the developer to produce fine-grained deposits is due undoubtedly to the solvent action of the sulphite on the silver halide emulsion. This not only reduces the size of each individual grain, but serves to prevent clustering or fusion during development of grains which are in close proximity to each other. The

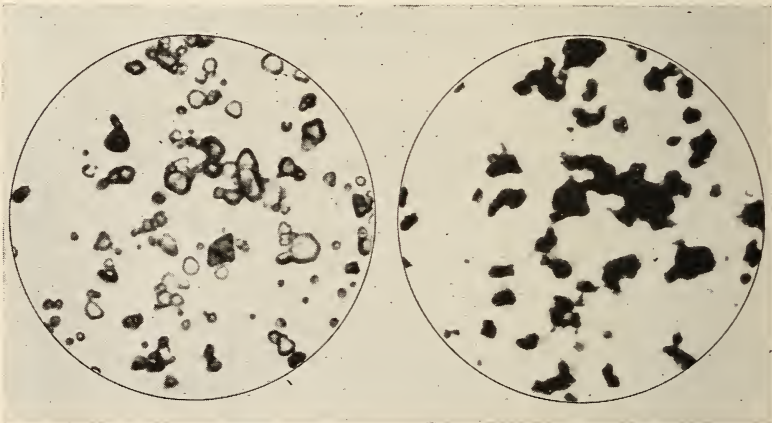


FIG. 1. Phomicrographs of emulsion before and after development.

reason for this is obvious from a study of Fig. 1. Fig. 1A shows a cluster of silver halide grains before development and Fig. 1B the same grains after development. The fusion or overlapping of adjacent grains is clearly shown. Obviously, if the size of each grain is reduced during development by virtue of the solvent action of the sulphite the distance between the surfaces of two adjacent grains is increased and the possibility of fusion is reduced.

The solvent action of the sulphite on the emulsion is revealed by the fact that the developer turns milky with use due to the presence of colloidal silver in suspension, while the walls of the developer tank become plated with metallic silver. Neither the presence of colloidal silver nor the plating out effect have any harmful effect on the developing solution.

Even with the higher speed emulsions, the graininess of negatives developed with this developer is of such a low order that it is necessary to stand quite close to the screen in order to detect any graininess in the picture whatsoever.

Moreover, the improved sharpness of the positive picture resulting from the reduced graininess of the negative greatly improves its general photographic quality.

b. Dilution of the developer. Jones and Hardy² showed that contrary to popular belief, dilution of a developer tends to increase graininess slightly when developing to a given contrast. This is undoubtedly a result of the diminished solvent action of the sulphite on the silver grains which takes place to some extent in most developing solutions.⁵ Dilution of the borax developer above has the effect of increasing graininess. It should be used in the concentration given.

6. *The degree of development.*

During development, at a constant temperature, contrast or gamma increases with time of development until a certain limit is reached. The contrast of the image at any moment compared with the limiting contrast which is possible in a measure of the degree of development at that instant.

It has been shown experimentally that development of any particular grain of an exposed emulsion starts at a point or points within or on the surface of the grain, and as development proceeds these specks of silver grow until the whole grain is reduced to silver.⁶ It is obvious, therefore, that if development is arrested at an early stage, only relatively small silver particles remain after removing the residual unexposed emulsion in the fixing bath; whereas if development is carried nearer to completion the size of the developed silver grains is of the same order as that of the original grains.

Since the visibility of the grains and grain clusters, which in turn determines graininess, is proportional to their size, it is apparent that a developed image of any given density obtained in one case by full exposure and low degree of development will in general be composed of smaller grains than one which received a short exposure and a full degree of development.

Projection tests with flashed motion picture film obtained by varying the exposure and degree of development have confirmed this theory.

In practice, however, the degree to which a negative is developed is governed largely by the brightness contrast of the subject. In the case of negative motion picture film the various scenes are developed for a sufficient length of time to produce a definite density contrast or difference in density between the highlights and shadows, although the particular density contrast to be taken as standard is a matter of personal choice. It is obvious, therefore, that negatives of standard density contrast with a minimum graininess can be produced by employing contrasty lighting for the subject and developing to a low degree of development.

In case the lighting of the object is not subject to control and if development must be forced, the borax developer will give a minimum of graininess.

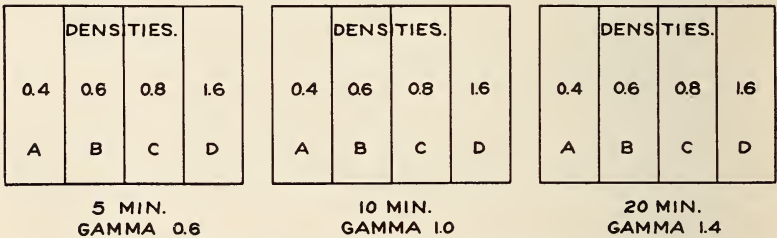


FIG. 2. Showing arrangement of densities on a single frame of motion picture negative film for observing graininess on projection.

If matched positive prints are made from negatives of the same subject developed to a low and high degree of contrast, respectively, within practical limits there is no difference in the graininess of the images. This is because low contrast development of the negative if offset by high contrast development of the positive.

In order to confirm further the above conclusions, and to determine the effect of printing through different negative densities, (obtained by varying the exposure and degree of development) on the graininess of a constant positive density obtained by a fixed degree of development, the following experiments were made.

Strips of negative motion picture film were exposed on a motion picture printer with a series of neutral density strips fitted in the gate. These consisted of gelatin containing a black dye and were entirely grainless. The density strips were so adjusted that on developing the negative to gammas (degrees of development) of 0.6, 1.0, and 1.4, respectively, the densities of the areas on each picture frame

measured 0.4, 0.8, 1.2, and 1.6, respectively. This was accomplished by trial and error.

The negative frames after development appeared as in Fig. 2.

Positive prints were then made from these negatives. These prints were all given the same degree of development and the exposure was so adjusted as to give a density of 0.4 from each density

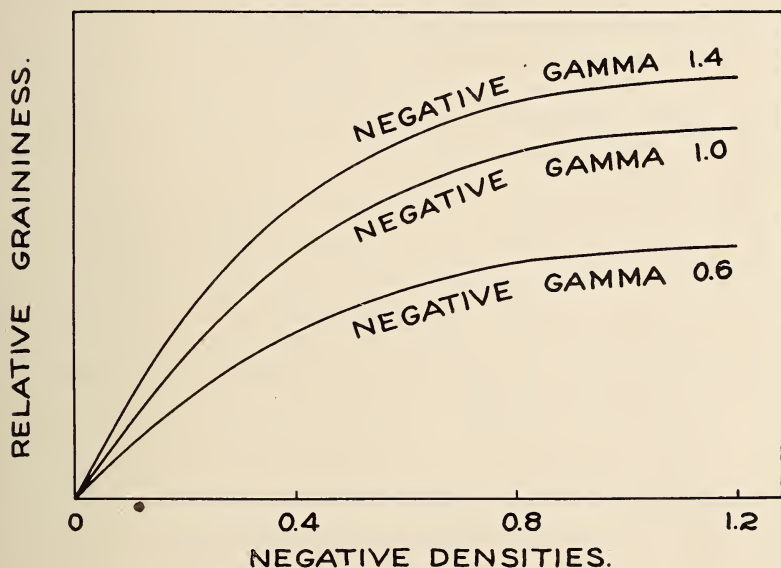


FIG. 3.

FIG. 3. Showing the variation of maximum graininess of the positive with increase in negative density (negative developed to different gammas).

strip of the negative. Referring to Fig. 2 step A was printed to a density of 0.4, then step B was printed to the same density, and so on.

The positive prints were then projected and the graininess of the various strips having a density of 0.4 were compared visually. Since the strips to be compared followed in rapid succession, a reliable comparison of graininess was possible. Three observers were employed for judging the projected prints and they all concurred in their findings. The projection tests revealed the following facts:

1. Maximum graininess of the positive appears in the tones having a density of about 0.4 to 0.5. This confirms the observations of Hardy and Jones.

2. Maximum graininess of the positive increases as the density of the negative increases from which it was printed. The increase is most rapid up to negative densities of around 0.8 and beyond this graininess increases only slightly. The effect is shown by the curves in Fig. 3 which are merely relative. This means that other conditions being equal, an increase in exposure of the negative, which in turn increases the density of the various tones, tends to increase graininess. This confirms the findings of Hardy and Jones.

3. In the case of a negative of given density contrast which has received a high degree of development, the maximum graininess of the positive print from this is greater than that of a similar print from a corresponding negative which received a low degree of development.

With regard to the observation above that an increase of exposure from $f/11$ to $f/3.5$ did not materially affect graininess, this would appear to be in contradiction to the results indicated by the above curves. In practice, however, owing to the limiting contrast which it is possible to obtain by over-development of positive motion picture film, it is necessary to secure a certain critical density-contrast in the negative in order to obtain a satisfactory positive print even with forced development. This density-contrast is of the order of 1.2, and assuming that the shadows have a density of 0.2, this means that a minimum highlight density of 1.4 is required in the negative. The above curves indicate that densities above this value do not give appreciably more graininess in the positive so that within a practical range of exposure, over-exposure of the negative has little effect on graininess.

7. The conditions during drying.

The experiments of Jones and Hardy² indicated that abnormal conditions during drying, such as prolonged drying in a humid atmosphere at relatively high temperatures, did not affect graininess. It is possible, however, that under certain circumstances incipient reticulation may produce a condition resembling graininess.

Graininess of Duplicates.

An increasing number of prints from duplicate negatives are being exhibited in present day theaters. Such duplicate prints are often made from projection positive prints and their graininess is usually very objectionable.

Up to within recent date it has not been possible to prepare satisfactory duplicate negatives with existing materials even when the original negative was available. If a negative is printed onto regular motion picture negative film so as to produce a master positive and in turn a duplicate negative is made from this, a print from the duplicate negative is objectionably grainy. This is a result of lack of resolving power of the emulsion used, or its inability to reproduce fine detail. During printing the emulsion is not able to record an image of the finest grains of the image being printed, so that each printing operation increases graininess.

Motion picture film is now available which is especially adapted for making duplicate negatives. It consists of a fine grained emulsion containing a yellow dye and has greatly improved resolving power so that the increase of graininess produced at each printing operation is reduced to a minimum. Details for handling this film have been given by Capstaff and Seymour.⁷ Prints from duplicate negatives made on this material are only slightly more grainy than prints from the original negative, and providing the original negative was developed in the borax developer above, the graininess of the print from the duplicate is no greater than that of a print from a negative developed in an ordinary developer.

It is obviously impossible to prepare a satisfactory duplicate negative from a regular projection positive print. Duplicates should always be made from the original negative whenever possible. The use of special duplicating film, however, will give the best possible results if only a projection positive is available.

Practical Recommendations.

Graininess in motion picture film can be reduced to a minimum by observing the following precautions.

1. Forced development of the negative should be avoided whenever possible since graininess increases as the degree of development of the negative increases. In some cases the necessity of forcing development can be avoided by employing contrasty lighting when photographing the subject so that only a relatively low degree of development is necessary to produce a negative of average density contrast.

This does not mean that negatives should be underdeveloped. If a negative of a flatly lighted subject is developed to a low degree of contrast it is necessary to force development of the positive, in

which case the positive will be just as grainy as if development of the negative was forced in the first place.

2. Develop ordinary and panchromatic motion picture negative film in the following developer which gives finer grained images than any other commercially used developer.

Fine Grain Developer for Motion Picture Negative Film.

	<i>Metric</i>	<i>Avoir.</i>
Elon	2 grams	13 oz.
Sodium sulphite (anhy. E. K. Co.)	100 "	41 lbs.
Hydroquinone	5 "	2 "
Borax	2 "	13 oz.
Water to make	1 liter	50 gallons.

Directions for Mixing: Owing to the high concentration of sulphite in this formula, it is somewhat difficult to dissolve all the chemicals unless directions are followed carefully.

First dissolve the elon in a small volume of water (about 125°F) and add the solution to the tank. Then dissolve approximately one-quarter of the sulphite separately in hot water (about 160°F) and add the hydroquinone without stirring until completely dissolved. Add this solution to the tank. Then dissolve the remainder of the sulphite in hot water (about 160°F), add the borax, and when dissolved pour the entire solution into the tank and dilute to the required volume with cold water.

With use, this developer may become slightly muddy but this is due to a suspension of colloidal silver which is likely to form and which is harmless and may be ignored. The tank usually becomes coated with a thin white deposit of silver but this does no harm.

The development time varies with the number of feet which have been processed but the average time for a fresh bath is from 10 to 15 minutes at 65°F. If a slower working developer is required the quantity of elon, hydroquinone and borax should be reduced. To obtain a faster working developer, increase the quantities of these chemicals. Dilution of the developer tends to destroy its ability to produce fine grained deposits.

The life of the developer is practically the same as that of the usual motion picture developers in general use. An idea of the increase in development time with use may be gained from the

fact that after 4,000 feet of film have been processed per 50 gallons of developer the development time is practically doubled.

The developer may be revived once or twice during its life by the addition of half the quantity of borax, elon, and hydroquinone originally used in the formula. A trace of sulphite should be added when mixing this reviving solution to prevent oxidation of the elon and hydroquinone.

This developer is somewhat sensitive to the effect of sodium bromide produced by the conversion of the silver bromide in the processed film to metallic silver. A comparatively fresh solution is therefore necessary for developing extreme under-exposures. With average studio exposures, however, excellent negatives can be obtained even with the partially exhausted developer.

3. When making duplicate negatives a minimum of graininess is insured by employing a special emulsion adapted for the purpose. Whenever possible duplicates should be made starting from the original negative and never from a projection positive unless this is the only record available.

4. Keep the camera lens clean. A dirty lens scatters light, causing lens flare. This reduces the brilliancy of the negative in the same manner as slightly fogging the negative before development. In order to offset the effect of lens flare it is necessary to force development of the negative, which in turn increases graininess.

¹ L. A. Jones and N. Deisch, "The Measurement of Graininess in Photographic Deposits," *J. Franklin Inst.* 190, 657, (1920).

² A. C. Hardy and L. A. Jones, "Graininess in Motion Picture Negatives and Positives," *Trans. S.M.P.E.* No. 14, 107 (1922); see also monograph on "The Physics of the Developed Photographic Image" by F. E. Ross, Chapter II, p. 21, Van Nostrand, N. Y. 1924.

³ R. Rogers, "Why Slide Film?" *Trans. S.M.P.E.*, 10, No. 28, 230, (1926).

⁴ J. I. Crabtree, "Handling Motion Picture Film at High Temperatures," *Trans. S.M.P.E.*, No. 19, 39, (1924).

⁵ M. L. Dundon and J. I. Crabtree, "Investigations on Photographic Developers" *Trans. S.M.P.E.*, No. 19, 35, (1924).

⁶ E. P. Wightman, "The Inside of the Photographic Plate," *Amer. Phot.* 329, June 1923.

⁷ J. G. Capstaff and M. W. Seymour, "The Duplication of Motion Picture Negatives" *Trans. S.M.P.E.*, 10, No. 28, 223, (1926).

DISCUSSION

MR. PALMER: Mr. Richardson has called attention to the question that has come up here a number of times that the theaters persist

in putting the projectors as high in the theater as they can get them. I want to suggest that the Secretary of the Society write a letter to Mr. Rothapfel of the Roxy theater expressing our appreciation of the fact that he has put his projectors in the center of the balcony of the theater.

MR. CRABTREE: I should like to ask if anybody can tell me if duplicate negatives are shipped to foreign countries for making prints in order to eliminate the duties on prints made here. When news reels are sent to Canada are duplicate or original prints sent?

MR. PALMER: In the case of our own company we make two negatives, one for this country and one for abroad.

MR. CRABTREE: How do you take care of so many contracts?

MR. WALLER: The original negative is shipped to England and this negative is shipped to other countries later if there is need for it. In your contracts with releasing companies you have to promise your negative is free from dupes. The only exception is some scene that cannot be taken twice. About news reels I cannot tell you.

MR. R. C. HUBBARD: I think I can answer Mr. Crabtree's question. They make one negative only and ship foreign prints from this country.

DR. HICKMAN: As Mr. Crabtree has dealt with this subject by a general survey of the field, perhaps he will forgive me if I answer Mr. Richardson on his behalf. In the application of the borax developer graininess can be reduced to almost zero. Mr. Crabtree showed these films in Hollywood and they produced quite a sensation. A number tried the borax developer, but it will probably not be used for large scale production because eighty pounds of sodium sulphite are required for every tank. Although this quantity does not mean a large expense where the rates are cut to the smallest amount, it may make all the difference between profit or loss. Here is a remedy for Mr. Richardson's complaint, but the manufacturer has been doing all he can to cure graininess. The remedy will cost somebody a fraction of a cent more per foot. I think it is up to the publicity men, technical editors of newspapers who have the welfare of the industry at heart, to persuade those who do the processing of film not to use the cheapest solution but the one which will give the best results, even if the price has to be adjusted.

MR. GRIFFIN: I have two things I should like to say: One is an answer about the Roxy. While we have been recommending that the projection room be placed in line with the center of the screen,

it appears that having done that in the Roxy they have to some extent lost what they were after. The projection distance at the Roxy is approximately 110 ft. and in view of the fact that fairly short focal length lenses must be used it is generally conceded that the projection is not quite as good as it would be with longer focal length lenses. I think that we should go a little carefully about suggesting to architects the placing of the projection room in line with the center of the screen, particularly where extremely short throws would be the result.

I should also like to bring to the attention of the Society the fact that Mr. Isaac and I were appointed by the American Projection Society to bring up the matter of film buckling. In the projection of pictures it has been found, and the complaint is very strong among the A.P.S. members, that film after projection buckles and it is impossible to get good definition. I should like discussion on this.

MR. RICHARDSON: I cannot agree with Mr. Griffin. What he says is quite all right, but it doesn't in any way change the fact that we want the projection room placed on a level with the screen center. If Mr. Rothaphel had not turned this matter over to an architect who knew more about architecture than he did about projection, he would not have had that trouble. That room could have been placed in the right location without injury to anything. What we want is a compromise between the long and short projection distances and always an angle that will not give any appreciable distortion.

MR. HILL: I have not seen the projection at the Roxy Theater, and I don't know how it compared with that of longer focal length lenses, but there is no reason why we cannot have good projection with short focus lenses. I gave a demonstration in New York last summer with a two-inch anastigmat lens and everybody was well satisfied with it. When Lowe's want a theater, instead of giving the architect a blank piece of paper, they show him where the projector and screen are to be and tell him to build the theater around them. The projection outfit is first put on the paper by their projection engineer.

With regard to buckled film, it is largely traceable to the reflector type of arc, and more especially to those which do not employ a condenser. The actual buckling of the film in the case of reflector arcs should not be greater than the buckling produced by other illuminating units delivering the same heat at the film aperture, but in the case of the reflector arc, the in-and-out-of-focus effect

produced by the buckling is much more noticeable upon the screen. Most of the reflector arcs have a condenser beam of very high relative aperture and as a consequence the projection lens is worked at full capacity which allows little or no tolerance in the focal plane. This results in noticeable want of focus on the screen even with very slight movement of the film at the aperture. Where the conventional condenser system is employed the objective lens is working at a much lower relative aperture since the smaller angle of the condenser beam produces almost identically the same effect as stopping down the projection lens with a diaphragm. The projection lens in this case has a consequently greater depth of focus, so that considerable warping or buckling may occur without producing any noticeable effect on the screen image.

MR. RICHARDSON: Replying to Mr. Griffin, the trouble is not so much with the lenses as it is with side distortion. When you come down to a three and a half inch lens or a four inch lens, the side distortion amounts to a lot. I believe short focus lenses can be made to give a perfectly good picture, but they can't take care of the side distortion.

MR. JENKINS: I have wondered many times why good quality prisms are not often used in front of the lenses in some houses to give perpendicular-to-screen projection. Let me give you a case: Here (indicating) are three machines, and only one is centered on the screen. I don't see why the projectors on the sides are not arranged at right angles to the middle one and fitted with prisms and the beam separated at the projection window only a few inches. That is only a suggestion.

Going back to what I had first in mind: On occasions I have had too short a throw or too great an angle and have found it perfectly satisfactory to introduce a pair of mirrors. It does two things where you find lenses are not corrected as well in the short as in the long focus. For one thing you can always bring the main projected beam in the middle of the screen. You can also avoid putting the booth where it will cut off any seats or cut any seats out of the house. I have wondered why it is not done oftener. In Atlantic City in 1896 we had the problem of projecting a 6x8 picture, and the depth of projection was only 12 feet, so we put the projecting machine behind the screen and projected towards the observers and into a mirror and turned it back on to the screen. Mirrors can be used; they don't have to be so large, and I wonder why they are not used oftener.

It can be done, and you don't have to rebuild the theater. You could correct the quality of the picture in many theaters already built.

MR. GRIFFIN: I understand that while I was out, Mr. Hill stated that buckle was due to reflector lamps. I know that this happened in theaters where there are no such lamps in operation. It is due to improper drying of film before it reaches the presentation stage, and that is why it was brought up at this time.

MR. COFFMAN: May I take this opportunity to call attention to the crying need for authoritative literature on laboratory theory and technique? At present, there seems to be no completely authoritative information of this character available to the laboratory worker. There is even a tendency to throw a veil of mystery over the whole subject. Many laboratory superintendents, including some of the best, are men who learned their profession by rule of thumb, and their basic theoretical knowledge is quite limited. Prize formulas were acquired from friends who took them around dark corners and swore them to eternal secrecy before imparting the mystic proportions. And finally, by trial and error, most of them have arrived at very satisfactory technique. But this is certainly a very unsatisfactory condition of affairs, and only one phase of a larger problem which would seem worthy of the serious attention of the Society—that is, the need for the establishment of authoritative courses of instruction in the various branches of motion picture theory and technique by our recognized Educational Institutions.

MR. POWRIE: I should like to refer back once more to graininess. Two years ago at Chicago I read a paper on the graininess in the projected image in which we made attempts to solve the problem by increasing the size of the negative film and reduce the image back to standard by optical projection. We have built a camera and have others in construction for the purpose of making a larger negative image and using an optical printer producing a far more perfect picture than we are able to get by the ordinary method of contact printing. The cameras that are being built at present run the film in a horizontal position, and the film is only a little wider than standard, 1-7/8 in., and gives an image four times the area. The question arises whether the increased amount of film would not be an objection but I truly believe that the question of cost is not so serious. Dr. Hickman suggested some alternative method of solving the problem and brought up the matter of cost. I do not think it is so much the

cost or a matter of increasing the size of the negative image and making the prints by projection. There is a good deal to say about making prints in an optical printer as against printing by contact. The camera being built for this purpose is called the "Magnigraph," and I think there is a great deal to be said on this point.

New Hyper-sensitizing Process.—G. Seeber announces that a Japanese investigator has discovered a gas that can be used for this process, especially for ciné film. It has been found that several gases act energetically on silver bromide, a few of them in a very short time, while others act so strongly that an accurate dose can not be administered. As is well known in the majority of cameras the length of film actually free from the magazines is comparatively short, but this is sufficient for the gas to get in its work. The great advantages of this method are first, that it is a dry method; the film is hyper-sensitized only just before exposure and there is no after fogging, as the film immediately leaves the gas zone. For commercial work it is suggested that a vent pipe may be fitted to the camera to allow excess gas to escape. Increased gas pressure as well as increased temperature gives greater sensitivity. It has not yet been determined how the gas acts, but provisionally it is assumed to be by catalysis. It is also said that a mixture of gases can be used as a color filter and that a color-sensitiveness is attained, such as has not yet been dreamed of. The gas may be dissolved in a liquid, as acetylene is in acetone, and a small bottle of 50 ccs. capacity, will suffice to sensitize 1200 meters of normal film. Such a small container may be placed inside the camera, or in the tripod head. It has also been suggested that the legs of metal tripods might be filled with the dissolved gas. "The cameraman of the future will be in the position at any time not only to instantly increase at will the sensitiveness of the film, but also by simultaneous use of the gas to make it color-sensitive. This special possibility will work out in the most favorable way in taking films in natural colors." (Phot. Ind. 1927, 25, 329).

WHY IS MAKE-UP COMPULSORY IN THE MOVIES?

V. A. STEWART*

MAKE-UP for the Movies is a greatly misunderstood art. Unfortunately the dramatic or speaking stage has had such an effect on the silent drama that nearly all of the artistes for the latter have been impregnated with wrong ideas as to the purpose of make-up.

When our grandfathers went to the theater, footlighting was the means whereby the major part of the stage was illuminated, and the actors came as near as possible to the footlights, so as to render visible all the facial expression they were capable of presenting, and that when the actual sound of speech might require assistance, unconscious lip-reading would be of great aid to this end.

Let us consider what was this source of light. In the early days candles were used; in Shakespeare's day reference is made to tallow dips for night entertainments, though performances were mostly given in daylight, as stage lighting at that time offered such insurmountable difficulties. Oil lamps later supplanted the candles. About the year 1800 gas for illuminating purposes was being popularized, and it stood to reason that the stage soon fell into line for this style of illuminant, first with the open flame burners, then with the Argand burner (named after its inventor) and then, though somewhat sparingly used, came the Welsbach incandescent gas light. Gas was hailed as a wonderful advance as it permitted dimming or increasing the light at will.

Around 1887 electric light made its presence felt—by the use of the Swan or the Edison carbon filament incandescent lamp.

Particular attention is called to the yellowish color that was given by the forms of illumination referred to, so that make-up became a necessity, and colors were devised to offset this yellowness. The paucity of light of the early illuminants compared with that of modern theater lighting compelled the use of large quantities of artificial coloring of the crudest description. Whitewash off the walls, red bricks rubbed together to produce a fine powder, lampblack or charcoal from burnt matches, were still in use in my younger days, and, later, the red for the lips was obtained from the cork of a bottle of liquid cochineal.

* Fox Film Corporation.

It was about 1870 that certain German actors introduced grease paint which immediately became generally adopted. Even then, on account of the small volume of light on the stage, powder was not considered essential, and the horrible greasy effect of the paint after it had been exposed to the heat of the footlights passed unnoticed, or at least was not a subject of criticism. One colored grease paint was applied over another until the actor looked like an oil painting, crude when viewed closely, but, at a distance, appeared smooth, with the colors blending into a pleasing result.

Making up used to take the old school of actors well over an hour before they were prepared to appear on the stage. The traditions then established anent make-up have been handed down to the present day, so that many of our actors are still making up for the old yellow lights although we now have Mazda and nitrogen-filled bulbs, spot-lights of single and twin carbon arcs, nitrogen Olivettes of high amperage, incandescent lamps, etc. Then, too, side lights and powerful overhead border lights are gradually causing footlights to be dispensed with. In spite of this greatly improved lighting no one, to the best of my knowledge, has tried to alter the make-ups to suit the new conditions.

It is a fixed physical law that the power of a point-source of light diminishes inversely as the square of the distance from it, and when footlights are only a few feet away from the actor and the border lights behind the proscenium arch are perhaps 20 feet away, and assuming that equal candle power was given by each at its source, we would be getting only about one-tenth the effective illumination from the borders that we would be getting from the "foots."

As is universally known, we are accustomed to seeing people on the street with the source of light coming from above them, causing all projecting parts of the face to cast a downward shadow. When footlights are used only a few feet from the actor the upward rays of light dispel the shadows to which we are so accustomed, so that artificial shadows have to replace the missing natural ones.

Of course actors are not lighting engineers and have given no thought to this very important point, so it is up to someone to try and demonstrate the assistance which this very vital aid would give to their expression and art.

As said before, all the old ideas of stage make-up have impregnated Motion Pictures of today. Those screen artists who were not originally stage actors have readily adopted the methods introduced

by their professional colleagues, with the awful results one sees on the screen every day, even among the stars. Their faces are so smeared with grease paint and light powder as to be almost inhuman in appearance. One genius thought he could improve conditions, and received some notoriety by the introduction of a yellow make-up. Quoting from a standard authority we read "the objections to yellow are that it is non-actinic, and, if the actor happens to step out of the rays of the arcs for a moment, or if he is shaded from the direct force of the light by another actor, his face photographs BLACK instantly." We are now speaking of ordinary or isochromatic film; panchromatic film will be referred to later.

To give detailed instructions for making up for the screen would require a paper far too long and intricate to read before this meeting, so I shall touch briefly on the most important points: Why should a male actor make up as pale as a female on the screen? In actual life there is a considerable difference, so why not reproduce it on the screen? Why should an actor make up his face ludicrously pale and leave his hands their natural color, so that when he lights his cigarette his hands are like two black paws by comparison with his over-made-up face? Why are women permitted to rouge their lips with a yellowish-red lipstick which photographs jet black and looks like a shaped strip of black court plaster stuck on the lips? Why do women redden the points of their finger nails so that they photograph like dog talons? Why do actors when wearing "sideburns" leave a space between their own hair and the artificially applied hirsute appendage? Why do they leave a big space between the inner ends of a screen moustache? So one could keep on—Why this? and Why that?

All because such little common sense has been applied to this art—and it *is* an art, when thoroughly analyzed.

Make-up should be as invisible as possible, so that a made-up motion picture actor by the slight addition of a little cheek rouge, should be able to go on the street without causing any comment.

Make-up in motion picture work is for the purpose of doing away with the retouching of the negative that is customary with ordinary photography. Without make-up all the subcutaneous colorations due to the iron and red corpuscles in the blood, that are invisible to the human eye, are caught by the actinically sensitive emulsion of the photographic negative.

I have taught several photographers a correct make-up for photography and they are so treating their subjects before taking

their pictures, thereby reducing the retouchers' art to a minimum. Most retouchers overdo their work so that the picture is generally altered into a vapid insipid face that one scarcely recognizes. It would be impossible to retouch a number of figures on a picture about the size of a postage stamp—one inch by three quarters of an inch—so that for motion picture photography, proper make-up becomes of paramount importance. To repeat, this statement is applicable to the film now mostly in use. Many directors are trying to do away with make-up by using tinted incandescent bulbs and panchromatic film, but as this millennium has not yet been reached we must approach things as they are, and must prepare the face to do away with the necessity of retouching. Well and good. How to set about it would have been easy if we had not to unlearn so much that the speaking stage actors have instilled into their silent brothers and sisters, and, unfortunately, we can see on the streets many examples of flappers so made up that their faces look much like the actresses of old when only poor lighting was being used, as in the good old days of "East Lynne."

Many books on make-up tell you that cold cream forms part of the make-up. Not so; cold cream is intended only for the purpose of cleansing the face so that the grease paint may be evenly applied, but, in any event, every bit of this cream should be entirely removed before putting on the paint, otherwise the cream (which melts at body temperature) will affect the make-up. In the studio the greasy appearance of an actors' make-up is frequently very noticeable, but the director usually wants his people in a hurry and does not give them time to patch their make-up which may have been on for hours.

This brings me to a point which I want to drive home: WHY use GREASE paints for motion picture make-up?

There are several so-called "liquid" enamels, made of powdered chalk, oxide of zinc, rose water, a little glycerine, and some witch hazel, which have a covering power equal to, if not better than, grease paint, and which will not show as greasy an effect as one normally gets in a studio without any make-up.

When I was still doing this class of work I had occasion to make up some Marimba Players, who were to be perched up near the top of a high set. I made them up with grease paint, and, after an hour or so of rehearsing, it was decided to shoot. I happened to catch sight of these gentlemen, and they were as shiny as well-oiled African slaves and we had to hold the scene until they were patched up.

The next day I used what I call "Water Colors" by which I mean the enamel, and the only attention I had to give these men was to lightly powder them after lunch. This, and other experiences, caused me to abandon all cold creams and grease paints from my make-up box, and, since then, I have taught all my pupils only the water make-up method. I once made-up several young ladies who were engaged at the Winter Garden, and, on the Saturday they had to hurry from the studio to be in time for their matinee. I added some rouge to their cheeks and with the enamel motion picture make-up they went on the stage that afternoon. I believe these girls have all now adopted water make-up entirely in place of the grease paint to which they had become accustomed.

This enamel has the power to cover all the blemishes and freckles which the flesh is heir to, and does not require the constant attention that grease paint does, and is far more easily removed at the end of the days' work. As a matter of fact, women need not remove it at all, but simply add a little rouge to give a healthy color to their cheeks, which, of course, is absent in the picture make-up. Furthermore, it does not soil men's collars or women's dresses. I hold no brief for any particular manufacturer, but attention should be called to the fact that there are several brands of liquid enamel on the market, some possessing the covering power that is so desirable, while others do not. The absence of the more expensive oxide of zinc is the cause of this. Prepared chalk is so much cheaper, and for ordinary purposes is good enough, but for motion picture work it is not the *eye* we must satisfy but the photographic emulsion which must be primarily considered. The excessive use of grease paint is apt to cause immobility of features, whereas enamel makes possible every movement of the face.

One manufacturer made a lip-stick for me according to my formula which had a quantity of blue mixed with it. This had the effect of photographically lightening it, so that, though the actress might daub it on to her heart's content, the camera did not pick it up too strongly. All my powders had their content of blue. We have all noticed that when our ceilings are being calsimined the whitening has a large quantity of blue added to it. It is of a pale blue color when first applied, yet it dries perfectly white, free from halation that might otherwise be there—hence my use of blue in all my colors. The lips should be tinted with a small water color brush so as not to have any grease there—which is frequently transferred in the act

of kissing. Never should an actor allow any of the foundation to get into the orbit of the eye. The overeye should be shaded with lavender—a color which has a preponderance of blue over the red—and, if there happens to be any foundation color there, the lavender is adulterated, and a mixed color is the result. Another thing: if grease paint be smeared all around and near to the eye it requires cold cream to remove it. All cold creams contain some preservative (generally sodium salicylate) and this may get in the eye and cause what is frequently mistaken for “Klieg Eye.” With the lighting used in studios, by means of hard and soft sources of illumination, we are practically reproducing daylight, yet in the dressing rooms of the actors there are some yellowish electric bulbs provided around the mirror in which the make-up is done. Generally one or two of the bulbs are in a direct line with the eye, so that the actor sees more of these lamps than he does of his own reflected image. Could anything be more ridiculous? The make-up may look perfectly good by the light in the dressing room, but absolutely bad when they walk into the lighted set. It is better that actors should make up by daylight when they are working in pictures. Even in this we see the old stage idea of making up by yellow light perpetuated, but though perfectly all right for the old stage make-up it is all wrong for pictures and modern stage lighting. In any event the position of the bulbs in relation to the eye is incorrect; the glare should be protected from the eye.

When a male actor is adding hair to his face for some particular part he always tries to match the crepe hair to his own, overlooking the fact that dead hair photographs several shades darker than that on the living body. Glorious blondes imagine that they will screen so as to show off this beautiful shade, not knowing that the film records yellow as black—necessitating back lighting through the fluffiest of hair. Frequently this back lighting is so strong as to put the face in shadow. Camera men frequently blame the actor for a dark make-up when the excessive back lighting is really at fault.

With ordinary film the slogan to be adopted should be: “Always err on the side of underdoing rather than applying too much make-up.” When we come to color photography we must apply the same rule, but more latitude may be used, as we need some red on the cheeks, on each side of the septum of the nose, on the tips of the ears, and the inner corners of the eyes. In fact, all we need for natural color photography is a perfect street make-up.

Regarding the excessive make-up of some of our leading men, I have several stills in my possession of one of these gentlemen whose make-up was such that on development his face was the only one in the group—all the other people with properly made up faces being under-developed. If they had been brought out on the negative the leading man would have been over-developed or "burnt out." As the negative is always developed up to the star this inequality of make-ups is frequently seen.

During my years at the Vitagraph, Commodore Blackton was forever after me to check up on the amount of lip rouge used by the women, but it was useless—they won by wearing me out with my continual complaints. Why directors and camera men do not control these things is one of the many shortcomings of this remarkably rapidly grown business. Some years ago I pointed this out to Mr. D. W. Griffith and he at once approved the idea and sent for the assistant director and instructed him to see that all make-ups conform to some sort of standard. How it worked out I never learned—but we all know the difficulty of trying to force principals into anything approaching system or order, though I met with a charming reversal of this rule with Miss Norma Talmadge. Her husband, Mr. Joe Schenck, asked me to consult with her on her make-up, and I found her a most receptive pupil.

When I started to make a study of the art of make-up I secured certain paint makers' catalogues, showing the colors they manufactured. These I had photographed in a hard light, a soft light, in daylight, and under studio conditions, using special plates having the same numbered emulsion as the film being used. Every department (costume, upholstery, etc.) was supplied with copies as a guide for their colorations. By means of these photographed representations of all colors I was enabled to evolve the proper colors in my make-up for the emulsion then being used.

Since writing the foregoing, there was published in the Liberty Magazine for April 9 an article entitled "How to Pass the Screen Test," by Brenda Ueland in which she says "Be sparing of the lip rouge. Red photographs black. Don't try to change the shape of the lips by rouge. It always shows." Later she says "Discard the yellow grease paint myth that actors clung to for so many years. Nobody can explain it. There is absolutely no photographic theory to account for its use. Yellow is non-actinic, and if the actor is shaded for a moment from the direct force of the light, his face photographs

black instantly." Further she says, "Don't come before the camera powdered a snow white. Some actresses think that the lighter they make themselves up the more youthful they will appear, whereas they only succeed in making themselves look like white billiard balls." Let us hope that though this article is printed in a non-theatrical paper, it will reach the eyes of the motion picture family, and have a good influence thereon.

Though I have had no experience in make-up for Technicolor or other process of color photography panchromatic film, the first thing I would do would be to photograph the color catalogs under the new conditions and work accordingly. It should be quite a simple matter to get some 8×10 plates coated with panchromatic emulsion, and record the colors as before specified, and then evolve the proper make-up colors to be used. Face powders can be procured in any color, and by mixing them with the rose water solution, enamels can be made to give the desired result. The old joke about the ghastly appearance of motion picture actors may yet come true.

Copies of previous issues of the TRANSACTIONS that are still available may be obtained on application to the secretary, Mr. L. C. Porter, Fifth and Sussex Streets, Harrison, New Jersey.

Nos. 1, 6, and 9 are out of print. The prices of the others are as follows:

Nos. 2 to 8, \$0.25 each; Nos. 10 to 15, \$1.00 each; Nos. 16, 17, 18, \$2.00 each; Nos. 19 to 28, \$1.25 each.

The supply of some issues is limited.

SOME FACTS CONCERNING PROJECTION LENSES

WILBUR B. RAYTON*

THE lenses used for the projection of both lantern slides and motion pictures are unique in the realm of optical instruments in their apparent insusceptibility to marked improvement. Within the last fifty years no kind of lens or other optical instrument has failed to receive the meticulous scrutiny of experienced and ingenious designers with a result which is a record of more or less continuous improvement. In projection lenses, on the other hand, there are two standard types which, although one of them is almost as old as photography and the other is beginning to assume an air of respectable old age, appear to meet the requirements of all kinds of projection in a fashion so satisfactory that noteworthy improvements have seemed to have been impossible. The records show not more than seven or eight patents granted on lenses said to be designed for projection and many of these admit reduction of cost rather than improved performance to have been the principal object of the invention.

The two types of lenses referred to are the Petzval portrait lens and the triplet construction due to H. Dennis Taylor. The first was announced in 1840, the second in 1895. The general type of the first is shown in Fig. 1 and of the second in Fig. 2. It is of no interest here to record the details of construction of these lenses and in fact impossible, for probably every manufacturer uses formulae for his lenses peculiar to himself none of which are exactly like the original Petzval construction or like any of the originally published triplets of Taylor. Within a comparatively few years after its birth the original Petzval form was subjected to modification by Dallmeyer, Voigtländer, and Zincke-Sommer. These modifications have become classic lens forms but there have been scores of other modifications which have never been honored by special mention nor have they deserved it for they have not represented any sufficient degree of originality. Later in the paper reference will be made to some fairly recent lenses which at first glance appear to differ considerably from the Petzval form but which on closer inspection are seen to be closely related to it.

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It appears to be pretty certain that the first commercial motion picture projectors sold in America were provided with Petzval lenses made by the Company with which the writer is now connected and the same type is now used almost universally for the projection of motion pictures and to some extent for the projection of lantern slides. For the latter form of projection, however, and for the projection of opaque objects by means of reflected light, the triplet lens

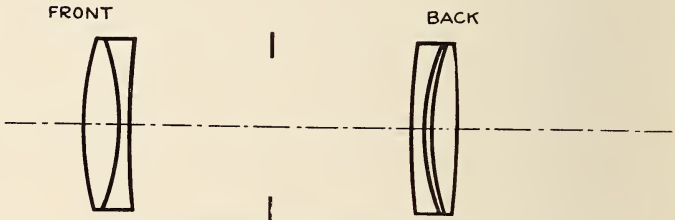


FIG. 1—Petzval Portrait Objective.

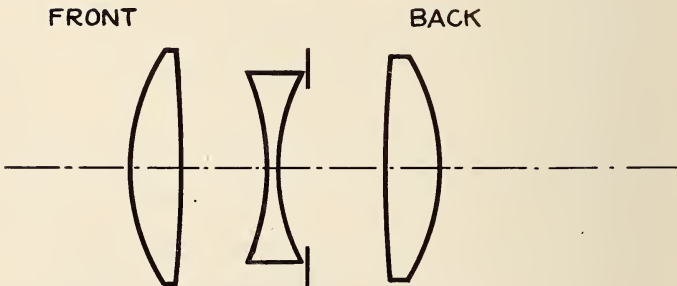


FIG. 2—Taylor Triplet.

is better adapted and possibly less expensive. Of these three kinds of projection, the last is the most remote from the interests of motion picture engineers and, while interesting enough from the standpoint of the demands it makes on the projection lens, will not be discussed further here.

The reasons why these two types of lenses are pre-eminently suited to these two respective kinds of projection are not difficult to find. Motion picture projection in the average house is a problem of projecting a picture which is small relative to the focal length of the lens but which must be magnified to a degree which can reasonably be called enormous and yet with sharp definition and with all the brilliance of illumination possible. In respect of magnification of the

image the projection lens is subjected to much more severe strain than the ordinary photographic lens. Consider the case in which we are projecting a film with a lens of 6 inch focal length and with a throw of 120 feet leading to a projected picture approximately 20 feet long. Viewed from the position of the projector the image on the screen would subtend exactly the same angle as the film would appear to subtend to an eye located 6 inches from it. Compared to the size of the picture as viewed from the projector, at 60 feet from the screen it would appear twice as large, at 20 feet six times as large. In other words at 20 feet from the screen the picture would look 6 times as large as would the film held 6 inches from the eye. A photograph on the other hand taken with a 6 inch lens would more likely be viewed at a distance of 12 inches or thereabouts so that, in comparison to the test to which an ordinary photographic objective is put, the projection lens in this hypothetical case is subjected to a strain no less than twelve times as severe. It is evident, therefore, that the lens which can successfully project motion pictures must have the finest definition possible. On the other hand the field of view which must be covered is much smaller than in ordinary photography. The long side of the film aperture subtends an angle somewhat less than 10 degrees for a projection lens of 6 inch focal length while a photographic objective of the universal anastigmat type may be called upon to cover a field five times as great.

In addition, however, to this requirement of extraordinarily fine definition there is the further requirement of high illuminating power. Now this property of the lens is gained by making its aperture large in comparison to its focal length within limitations which will be mentioned later. This practice, in all lens construction, leads to deterioration of definition because of the defect known as spherical zones. While it is generally possible to cause the light which, coming from any given object point, passes through the marginal zone of the lens to unite in the same image point as the rays which pass through the center of the lens, it is usually impossible to prevent the rays which pass through the intermediate zones from converging to points somewhat nearer the lens. The greater the aperture of the lens in comparison to the focal length the more troublesome becomes this defect. The two requirements of the lens needed for motion picture projection are therefore mutually antagonistic. They are met, however, to the most satisfactory degree by the Petzval type of lens which is characterized by its very excellent definition over a

small area even when the aperture of the lens is nearly half its focal length.

In lantern slide projection on the other hand the magnification required is usually not more than a third of that required for motion picture projection and therefore the matter of high aperture is of relatively less importance. The field of view to be covered, however, is often larger. These requirements are better met by a lens of smaller relative aperture than the Petzval and one with considerably greater covering power, i.e., ability to form an image of satisfactory quality of a fairly extended object. Such a lens is the triple anastigmat. It performs excellently and is relatively inexpensive. It may be of interest, however, to point out that lantern slide projection from a motion picture projection booth involves no greater angle of field of view than is required of the motion picture projection lens and such projection is often satisfactorily accomplished with a single achromatic lens or a telescope objective.

Up to this point no reference has been made to the influence of the type of illumination employed upon the demands made upon the projection lens but the implication was made a few minutes ago that it might not always follow that increased illumination would be gained by increasing the relative aperture of the projection lens. In fact, in order to insure that an increase in the relative aperture of the projection lens shall be effective, it is necessary to see that the aperture of the illuminating system be sufficiently large.

In order to pursue this matter a little further it will be convenient to introduce the expression "angular aperture." If an eye be placed at the center of the film gate and turned towards the objective, the largest circle of light visible subtends at the eye an angle which we call the angular aperture of the objective. Similarly, if the eye turns towards the illuminating system the largest circle of light seen subtends at the eye an angle which is the angular aperture of the illuminating system. Now, in so far as the central point of the film gate is concerned, there is no gain in illumination if the angular aperture of the projection lens is increased to a value greater than the angular aperture of the illuminating system. Now, the angular aperture of the illuminating system is a complex thing. In addition to the physical dimensions of the optical units of which it is composed it depends upon the size of the light source and upon the location of the image of the light source with respect to the film gate. The illustration in Fig. 3 will help to illustrate this point. Here a motion picture pro-

jection system has been reduced to its lowest terms, the source of light, the condenser, the film gate and the objective. The solid lines limit the pencil of light which, originating in the central point of the light source, is converged by the condensing lens into an image in the plane of the objective. The dotted lines intersecting in the center of the film gate at the point P' measure the angular aperture of the illuminating system only under the condition that the source be large enough to fill the dotted cone extending to the left from the condenser to the point P which is the image formed by the condenser of the point P' . The illustration shows the source just large enough to

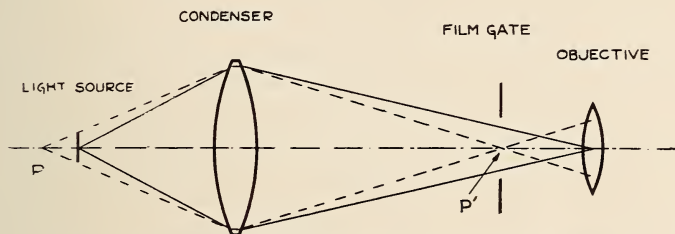


FIG. 3—Schematic Motion Picture Projection System.

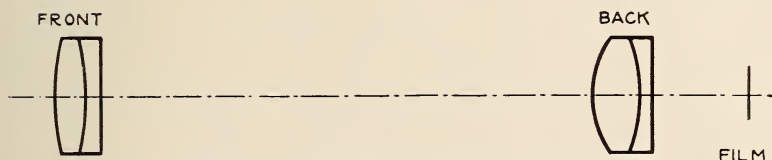


FIG. 4—Projection Objective with Short Back Focus.

meet this condition. If the light source were smaller than shown in this sketch it would be impossible for the condenser to appear filled with light when viewed from the point P' . This follows from the fact that no ray of light leaving any point of the light source other than the extreme margin can pass through the margin of the condenser and also through P' . The figure also shows that the angular aperture of the objective is larger than that of the illuminating system since the dotted lines do not reach to the margin of the lens. No light, therefore, reaches the marginal zone and the excess diameter is useless in so far as the center of the field, at least, is concerned. For the same light source the angular aperture of the illuminating system can be increased or decreased by altering any one of several dimensions of the system but consideration of these points would lead

us into a field too remote from the subject of this paper to justify it.

After meeting to the best possible advantage all the conditions which must be imposed upon an illuminating system for motion picture projection, the ordinary condenser type has an angular aperture of about 20 degrees when adjusted to best advantage for a projection lens of 6 inch focal length. The reflector arc has a higher angular aperture. The most popular type reaches a value of 27 degrees.

Now it has been frequently observed that some projection lenses which present a very satisfactory image with condenser illumination do not perform so well when used with a reflector arc. This is certainly possible if the angular aperture of the objective is larger than that of the condenser illuminating system. Under this condition less than the full aperture of the objective is used for the imagery of any given point of the film when condensers are used whereas more of the aperture or the full aperture would be used when the change was made to the reflector arc. Because of the spherical zones in the projection lens, which are always present to a greater or less degree, or because of deliberate over-correction of spherical aberration the lens might fail to give satisfactory projection with a reflector arc even though its performance with condensers was entirely satisfactory. It would be more or less accidental if a lens designed for condenser illumination happened to be at the same time adjusted to the best condition for reflector arcs. If reflector arcs are to be used with their full efficiency they require projection lenses which are designed to give the best possible image with very high relative apertures.

In spite of all its merits, the Petzval lens cannot be absolutely corrected simultaneously for astigmatism and flatness of field even for the small angular fields of view involved in the average motion picture projection. The margin of the field is, therefore, never as well defined as the center. This defect escapes the notice of the average patron of the theaters because the action is generally concentrated within the central two-thirds or less of the picture area and the material which fills up the margin does little more than constitute a frame for the interesting part of the picture. It is natural to inquire, however, why an anastigmat construction such as is used in photography would not offer better projection. The answer is that while the anastigmat produces well defined pictures of much greater angular extent than is required of a projection lens, it does it only at relative

apertures which are less than those required in projection objectives. If an anastigmat be increased in diameter to give the relative apertures required of motion picture objectives the increase in spherical zones becomes so great that there is very perceptible deterioration of definition in the very center of the picture. The Petzval construction is characterized by small spherical zones and for this reason has been the favorite lens for the projection of motion pictures since the beginning of the art.

There has developed recently, however, a desire to reduce the projection distance below the previous average value without correspondingly decreasing the size of the projected picture. This will lead either to pictures whose margins are very poorly defined or else to the adoption of an anastigmat lens. If the latter expedient be resorted to, either the relative aperture of the lens must be decreased or less sharp definition be accepted over the whole area of the picture than is now expected. If the relative aperture be reduced in the interest of definition then illumination must suffer unless light sources of very high intensity become available. Another difficulty may be presented in the increased difficulty of getting an appearance of even illumination because of the greater angle of incidence on the screen of the pencils of light forming the marginal image. It is very doubtful whether the advantages which follow from the use of the very short projection distance are not overbalanced by the disadvantages in the quality of the projected picture.

In the early part of the paper it was promised that reference would be made later to some recent lenses which differ from the Petzval type of lens. Two patents have been issued which describe lenses very similar to each other, one of which claims decreased cost of production and the other increased illumination. These lenses, both of which are on the market, differ from the Petzval construction in that the back component is relatively close to the film gate. It may be argued, however, that the difference in construction between these lenses and the Petzval is more apparent than real. Referring again to Fig. 1, the front component is seen to resemble very much a telescope objective. As a photographic or projection objective, a telescope objective would be unsatisfactory because of its very limited field of sharp definition and because of its insufficient relative aperture. By adding to the telescope objective a second component, however, the combined focal length can be very much decreased thereby gaining the necessary speed and, further, by a suitable choice

of shapes and glasses of the lenses of the rear component and its distance from the front lens, the useful field of view can be extended. Such, in fact, may be said to be the principle of construction of the Petzval lens. The front component differs somewhat but not greatly from a telescope objective; the back component adds to the light gathering power and to the field of view. Viewed in this light, the new lenses the type of which is represented in Fig. 4 do not differ greatly from the Petzval. From the standpoint of performance, nothing is claimed for the one while for the other it is claimed that it leads to a brighter image. This can be true, however, only if it can be shown that the construction makes it possible to produce lenses of higher relative aperture than other types and that the angular aperture of the illuminating system is large enough to make use of the enlarged aperture of the projection lens. Otherwise the mere fact of making the back focus short or, in other words, of bringing one of the components close to the film gate cannot have any effect on brightness of image.

DISCUSSION

MR. TOWNSEND: As I understand Mr. Rayton, this latter type of lens theoretically does not give more light, but most projectionists will say that it does give considerably more so as to be perceptible to the eye. I wonder how that could be explained.

MR. RAYTON: In photometric comparisons of these lenses, all of which were reduced to the same relative aperture, we found no difference. A slight difference will exist in the case of a lens whose back component is cemented as compared with one whose back component is not cemented because of loss of light at the uncemented surfaces. When the lenses are diaphragmed to the same relative aperture, there is no other difference.

MR. EGELER: With the objective and 16 mm. film the projection distance is often a quarter or a fifth that of the 35 mm. film. Should it not be possible to use certain types of construction for the smaller film which would allow the large aperture because the ratio in film width is 2:1 whereas projection distance would of the ratio of 4:1 or figures of that order?

MR. RAYTON: As a rule, the angular field in projecting the half size film is at least as great as in ordinary theater projection of full size film. While special lens constructions may be in use in amateur work, I was not thinking of that type of projection.

A POLYGONAL FLOODLIGHTING MIRROR

FRANK BENFORD* AND M. W. PALMER**

Synopsis

The reasons that make it desirable for the motion picture studio to employ large floodlighting units are the high levels of illumination required for high speed photography and the peculiar sensitivity characteristic of the photographic film. These two factors indicate the use of a high intensity arc, and there is a national tendency to take the high intensity searchlight just as it has been developed for military service and by refocusing get a beam of wide spread. The defects of this method are illustrated and it is shown that a more suitable optical arrangement is to use a polygonal mirror rather than a paraboloid. The method of computing the dimensions of the polygons is given along with data on a photometric comparison of the two types of reflectors.

Studio Use of High Power Floodlights.

THE intensity of illumination required for the taking of motion pictures is of the general order of one hundred times the illumination under which we may comfortably work and read in our offices and homes, and the motion picture art requires much special lighting equipment to attain these high intensities. There is a further difference between the every day use of artificial illuminants and studio practice, and that is the obvious fact that in the office or home we are interested in the reaction of the eye, but in the studio we are interested in the reaction of the photographic film. The film centers its reaction on the violet and ultra-violet regions of the spectrum, and as a result the brightness of illumination as measured by the eye with the aid of a photometer is not a reliable measure of the photographic intensity. One of the outstanding results of this difference is the use in studios of several light sources, the high intensity arc among them, that are not commonly considered as illuminants for floodlighting purposes.

The high intensity arc is essentially a high current arc and this fact alone leads to a few large units rather than a number of small ones, and the unique demands here made call for a type of unit that is not essential in any other phase of the illuminating art.

As motion picture sets have become increasingly larger, it has become more and more necessary to use high intensity sources with

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some means of carrying the light from this source into the set. The prevailing method, up to this time, has been to use parabolic mirrors of 24 and 36 inch diameter, with a 150 ampere arc. These mirrors are very expensive, heavy, and easily breakable; a mirror frequently breaks in the first week of use. Consequently, the studios have welcomed this polygonal mirror from the economic, as well as the practical angle.

Floodlight Beam from Parabolic Mirror.

A floodlight beam from a parabolic mirror has certain peculiarities that seriously interfere with its usefulness as a source of general illumination. On the other hand it has certain excellent features and it has been successfully used in many studios. The mirror is usually mounted in a barrel to support it and to cut off the radiation of arc light to the sides and rear. This barrel enters into the optics of the beam and in every case where the barrel is of normal proportions it leads to a loss of light as can be illustrated by the aid of Figs. 1 and 2.

If the arc is moved from the focal point along the axis of projection so as to increase its distance from the mirror the beam may be made to converge to any desired degree. After the beam passes through the point of convergence it becomes divergent and spreads to the desired width. This beam when formed by the use of a searchlight mirror of the precision type has great smoothness of texture, being generally free from images or dark spots, but there are two features about it that must be ranked as defects of the first order. The edges of the beam are much brighter than the central parts. This change in brightness is gradual and therefore often not strikingly apparent to the eye, but it nevertheless reduces the effectiveness of the central parts and wastes light around the edges where it is not useful. The second defect is the presence of a dark spot or shadow of the lamp mechanism that appears in the exact center and along a radial zone to the upper edge of the beam. This is illustrated in Fig. 3 where the curve and sketches are from physical measurements made on an experimental floodlight beam. This mechanism shadow can be reduced in harmfulness but not entirely eliminated by moving the heads several inches below the axis. This moves the spot towards the top of the beam, but does not entirely remove it from the field. In Fig. 7, curve A, the distribution is seen to be unsuitable for general floodlighting, although in the particular floodlight of which this is an actual test, the lamp was lowered several inches in order to avoid the central dark spot.

The convergent form of the beam is also accompanied by the secondary effects as follows:

(1) An abnormal loss of light due to the convergent beam falling on the mechanism of the lamps heads;

(2) An overheating of the front door that is occasionally used. In cases of extreme convergence the glass may be heated nearly to the melting point, with a severe loss in clearness and transmission;

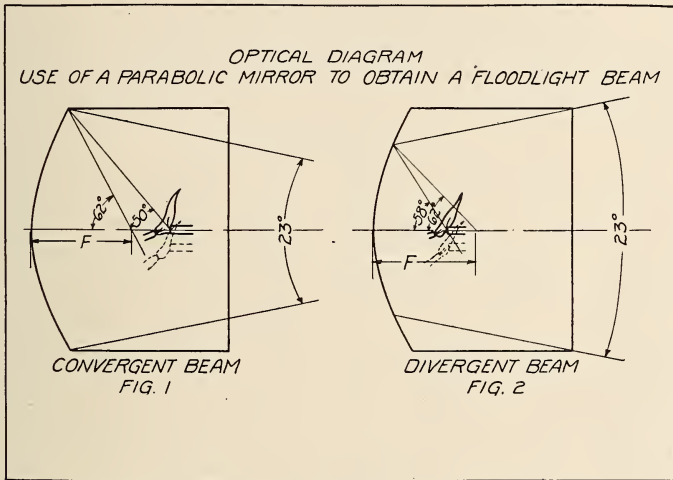


FIG. 1—Optical sketch of light source placed to give a convergent beam from a paraboloid. This arrangement does not involve a loss of light on the inside of the barrel, but the interference of the head mechanism may be serious.

FIG. 2—Optical sketch of light source placed to give a divergent beam. There is here considerable interference by the barrel. The lamp heads may be lowered to throw the lamp shadow towards the outer part of the beam.

(3) A decrease in the amount of light incident upon the mirror.

The alternative plan is to move the lamp closer to the mirror. This, in general, produces the same results as before, with certain variations that are easily recognized. There is a loss of light in the beam because the extra light that falls upon the mirror is reflected onto the inside of the barrel, and even some of the light that is ordinarily useful is lost in the same way. In the typical case illustrated in Figs. 1 and 2 the parallel beam being made equal to 100, the convergent beam as it leaves the effective part of the mirror is 90, and the divergent beam is 72. In a particular design to be noted later the barrel loss was about twice as great as in this example. Thus

any refocusing of the lamp either towards or away from the mirror leads to a loss of beam flux, and the wider the beam is made the more serious does this loss become.

The distribution of light in the initially divergent beam is very bad. See the two left hand sketches of Fig. 3. A bright ring of high

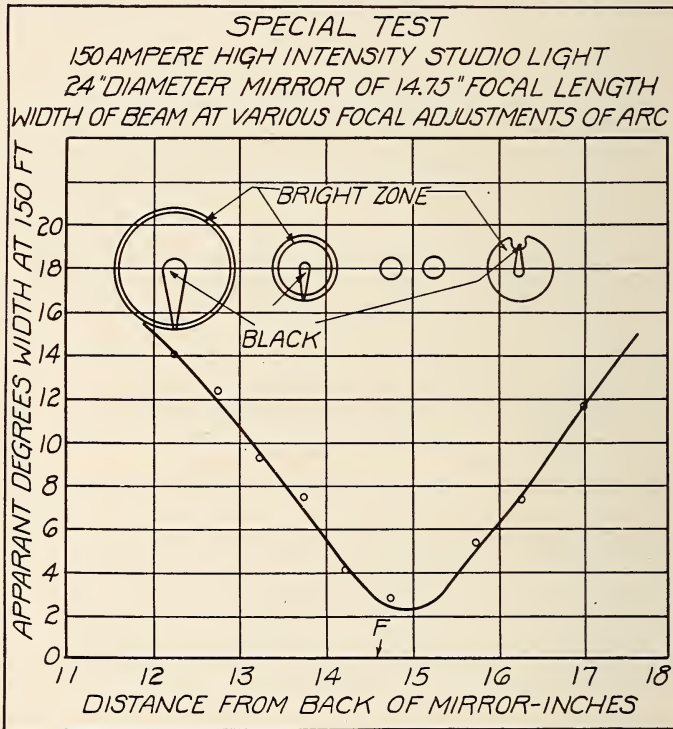


Fig. 3—A photometric exploration for beam outline and width when using a paraboloid and a high intensity arc adjusted along the optical axis.

intensity encircles the beam, and inside this the intensities fall off to low values. The shadow of the lamp mechanism is not so sharply outlined as before, but it still must be moved from the center or otherwise avoided.

The Polygonal Mirror.

During the last few years a considerable amount of attention has been given to the theory and performance of a type of mirror known as the sectional or polygonal mirror. This mirror is made of a metal

back spun to a parabolic form, and lined on its concave side by numerous pieces of flat mirror glass. It has been demonstrated* both mathematically and by actual test that if certain proportions are observed in forming the individual mirrors the resultant beam will be free from images and highly uniform in intensity in its central part. The basic equation of such a mirror is:

$$l_a + s_0 \cos^2 \frac{a}{2} \cos a = p_a \sin a + s_0 \cos \frac{a}{2}$$

where

l_a is the angular length of a section, measured along a radial centerline;

p_a is the angular width of a section, or 360 divided by the number of mirrors in the zone;

s_0 is the angular diameter of the light source measured from the vertex of the complete mirror;

a is the angle, measured from the axis to the center of the particular section being designed.

When the conditions of this equation are fulfilled each mirror will give a beam that coincides in direction and in average size with all the other individual beams. With all beams covering the same field it is self evident that the action of any one particular section is not of vital importance. Several trial mirrors were built with a commercial grade of rolled glass mirrors, but it was found that the imperfections in the glass set up zones or images in the beam. These images were not of great strength or of much visual prominence, but they rendered the beam defective, particularly if it was moved during the taking of a scene. Later, mirrors of plate glass were used, and they gave a beam almost wholly free from this defect. Only the outer zones of the beam show traces of the individual beams.

In Fig. 4 is illustrated a front view of a 36 inch diameter mirror designed to give a beam 30 degrees in diameter. There are three zones of mirrors. The central zone contains four sections, the intermediate zone nine, and the outer zone twelve sections. The beam from each section has a general resemblance in outline to the form of the sections in the diagram. The sections are here seen in perspective and are foreshortened somewhat, which has the effect of making them appear more nearly equal in length and breadth than they actually

* Benford, "Studies in the Projection of Light," General Electric Review Dec., 1925, and March, 1923.

are. The optical relation of the image back of each section to the outline of that section carries this foreshortening still further and the individual beam becomes more nearly equal in the two diameters corresponding to the two centerlines of the section of mirror. As

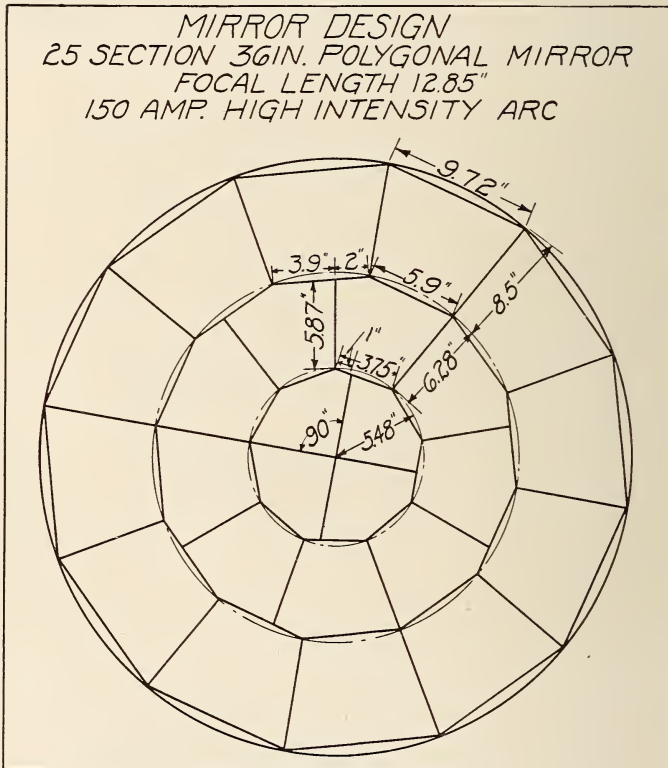


FIG. 4—A typical form taken by a paraboloidal shell when lined with polygons designed to give individual beams of uniform sectional area.

an illustration, the average width of a mirror in the outer zone is 7.81 in. and the length is 8.50 in., but the beam from this mirror is almost square in section, and each of these square beams is rotated 30 deg. from the orientation of the beam from an adjacent mirror in the same zone. As a result of the way in which the corners of the beams are spaced around the edge of the combined beam they are almost wholly lost to view, and the beam appears circular in outline with a series of 48 faint scallops equally spaced around the edge. The

beam from all twenty-five sections has twenty-five individual beams with over one hundred scallops and the multiple form of the beam is visible only around the extreme edges and not at all in the center.

This 25 section mirror gives 25 individual beams from the 25 images that are back of the mirrors, and an opaque object in the beam therefore casts 25 shadows. This feature has been given some study



Fig. 5—A study of the shadows formed by a polygonal mirror. There is a separate shadow for each section of the polygon, 16 in this particular case.

because it was once thought that this compound shadow might be objectionable. It has since been found that in studio practice this form of shadow is to be preferred to the sharp and clear shadow from a parabolic mirror. There may, of course, be exceptional cases where the sharp shadows are to be preferred, and therefore data on the subject is of importance.

In taking the shadow photograph of Fig. 5 the five subjects were arranged as follows. The man on the left was 5 feet from the white screen. The others were spaced back at 5 foot intervals so that the man on the right was 25 feet from the screen. The floodlight itself was 60 feet away on a line normal to the center. The progressive separation of individual shadows produces a peculiar type of com-

posite shadow but in the presence of other light the composite shadow loses much of its "cubist" tone and becomes merely soft-edged and indistinct.

If the harsh shadows of direct sunlight are desired in portraiture this beam will give the desired results. To illustrate this a "close up" was taken with the sitter at 25 feet from the mirror. The photograph of Fig. 6 shows clear and distinct shadows and there is but little evidence of the multiple character of the beam.

Test Data.

Among the tests that have been made with the polygonal mirror there is one that is of direct interest to the Society of Motion Picture Engineers, and the data of this test will be given in preference to several other tests that were more elaborate and of higher accuracy. This test was made at the Famous Players-Lasky Studio, and certain features of the test therefore are a faithful duplication of studio practice.

A 150 ampere arc was focused (on the axis) to give the designed spread of 30 deg. It was found that, due to mechanical limitations, the arc could not be brought closer than 12.75 in. to the mirror, whereas the designed operating focal length was 12.20 in. The effect on the beam was not great because the arc is not sensitive to focal adjustment and to produce a sensible change in beam formation the lamp must be moved through several inches.

The beam was directed against a wall one hundred feet away with the center of the beam 5 feet above floor level. Reading stations were marked off at 5 foot intervals for the width of the beam, and photometer readings were taken at each, making two complete traverses of the beam. Constant current of 150 amperes was held in this and in the test that followed.

The measured beam formation is given by curve *B* of Fig. 7. This curve shows a central zone 15 degrees wide over which the beam is substantially uniform in intensity and an annular zone 7 degrees wide of gradually decreasing intensity. The width of this outer zone is abnormally wide due to interference by the lamp barrel with the light from the outer zone of the mirrors. With a barrel designed to conform to the beam dimension the beam will have the form of curve *A*, Fig. 8, which is a computed curve. The central zone of uniform intensity is nearly 20 degrees wide, and the whole width is 32 deg. Curve *B* of this Figure is the computed beam, taking account of

the loss of light through the interference of the barrel, and curve *C* is the form of characteristic obtained by actual test. The disagree-



FIG. 6—A study of face shadows from a 15 section polygonal mirror at 25 feet distance.

ment between the two is probably due to the fact that only six readings were taken at each point in the beam.

The quantity of light in the full beam is computed to be 322,000 lumens, and the barrel interference reduces this to 254,000 lumens. This light includes the orange light of the flame, and the floodlight

beam is noticeably whiter than the searchlight beam produced by the same arc. This color difference arises, of course, from the flame light being outside of the true searchlight beam and hence lost for projection purposes.

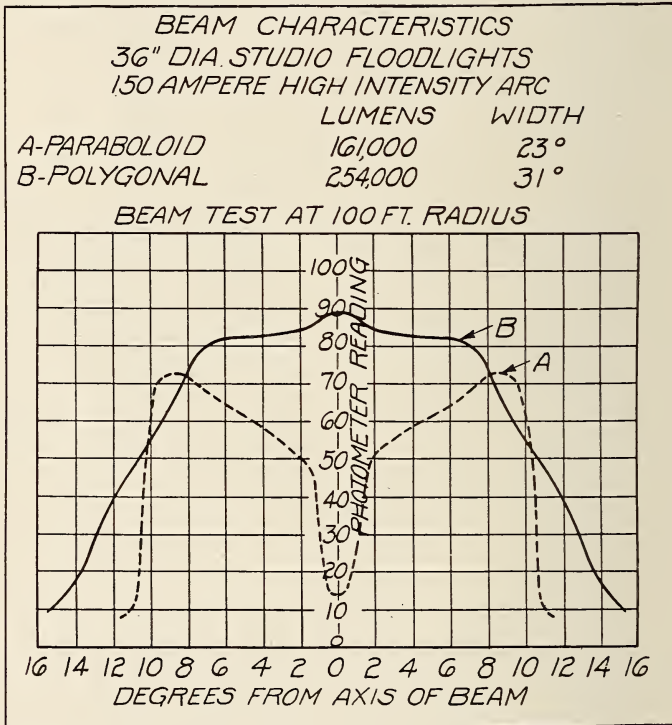


Fig. 7—Beam characteristics of a 150 ampere arc with A—36 in. dia. paraboloidal mirror; B—36 in. dia. 25 section polygonal mirror.

Under the same conditions of test the parabolic mirror gave a characteristic distribution as shown by curve A, Fig. 7. The central dark spot is still strongly evident despite the fact that the lamp was lowered several inches below the axis. The ring of high intensity around the edge of the beam is highly characteristic of this type of mirror, and the wider the beam is spread the more pronounced will this maximum become.

It may not be out of place to remark that the sectional mirror is, next to the plane mirror, the oldest type known. The Roman fleet

at the siege of Syracuse is supposed to have been set on fire by sunlight reflected from a mirror built by Archimedes. Regardless of the accuracy of this account, the sectional mirror has been used on

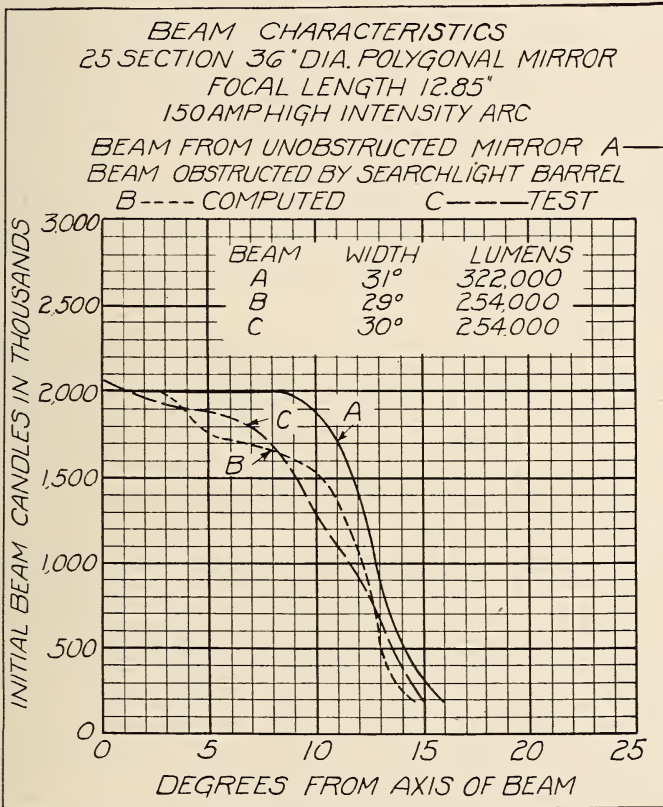


FIG. 8—A study of the effects of barrel interference with the beam from a polygonal mirror: A—Unobstructed beam; B—Obstructed beam (computed); C—Obstructed beam (test).

various occasions, particularly in theatrical work, and therefore the basic conception of a sectional or polygonal mirror is not a matter of current history. The new feature of the present mirror is the manner in which the individual mirrors are formed so as to give a multiplicity of beams, each agreeing as far as possible with all the other beams both in direction and in size.

Among the obvious advantages of this type of mirror are: cost, ease of repair, lessening of damage when overheated, greater economy of light projection, and a superior type of distribution of the light in the beam.

DISCUSSION

MR. PORTER: The type of reflector described is that designed for the relatively highly concentrated source of the arc; has Mr. Benford used a 10-kilowatt Mazda lamp?

MR. BENFORD: In designing this mirror, if you want to do a nice job, you correct for the light source. In designing for a 40° incandescent beam, the mirror makes 36° width and 4° width are contributed by the light-source. One could work well with the incandescent lamp.

MR. EGELER: From an artistic standpoint it seems undesirable to have extremely sharp shadows. In connection with the application of these units I should like to ask whether these relatively sharp shadows are not objectionable, and whether the units are not used with diffusers that eliminate the shadows. Is there an extremely wide spread of the beam with a sharp shadow or a good control of the light which is then diffused?

MR. PALMER: I can answer Mr. Egeler's question by saying that in the first place it isn't often that just one of these lamps is used at a time. In that case, one would help out the shadows of the other. If it was necessary to have a diffused shadow without showing the peculiar effect seen on the screen, it could be accomplished by putting a ground glass on the lamp for the time being. Even with the ground glass I believe one would get more light than from an ordinary parabolic mirror without the glass.

MR. JENKINS: I should like to ask if this same development has been applied to ellipsoidal reflectors?

MR. BENFORD: That would be entirely possible if you wanted to concentrate not to the maximum degree but over some definite area. I think that would be very useful, and I don't see any difficulty in carrying out the design.

MR. L. A. JONES: I should like to call attention to a polygonal reflector which was described some time ago in these TRANSACTIONS. This was not designed from the same view point as that taken by Mr. Benford. The reflectors I refer to were designed specifically for flood light, that is obtaining fairly uniform illumination over a

relatively large area. These polygonal reflectors were constructed for use with 3000 watt tungsten lamps and we have been using 45 of them in a color motion picture studio in Rochester. They have proven very satisfactory for flood lighting and have a very high coefficient of utilization. In general a group of nine of these are assembled fairly close together, but even so the spatial distribution is relatively great so that the shadows formed are not very distinct. In case a sharply defined shadow is wanted we find it necessary to use a spot light such as a 10 KW lamp mounted in a parabolic search light reflector.

MR. MAYER: I should like to gather more information with regard to concentrating a beam of light from such a mirror. Would it be possible to concentrate the light by mirrors, that is, the smaller the individual mirror and the more of them, the greater the concentration?

MR. BENFORD: Yes.

MR. RICHARDSON: Is it not a fact that the shadow effect is one application of the umbra and penumbra?

MR. BENFORD: Yes.

Drs. A. R. Irvine and M. F. Weyman report (*J. Amer. Med. Assoc.*) that more eye-fatigue was caused by 45 minutes reading than viewing black and white motion pictures for 1½ hours, one hundred and fifty persons being examined. No less than 68 per cent of the subjects showed a 43 per cent loss of acuity of vision after 45 minutes reading and only 21 per cent after seeing the pictures. "An interesting side-light on this observation was that when a group had been reading for 45 minutes and was sent immediately into a projection room, and viewed a picture for 1½ hours, 83 per cent of those who had showed a fall showed an improvement after seeing the picture." This is explained by assuming that the subject was bodily tired or totally fatigued on entering the room, and the entertainment of the picture provided relaxation for them. In other words when your brain and eyes are tired 'go to the movies.' In another group of 60 persons it was found that 53 per cent showed loss of acuity after seeing black and white pictures, while only 48 per cent showed loss of acuity after seeing colored pictures of the Technicolor type. In another group of 153 people there was no difference in black and white and colored pictures. (*Sci. Amer.* 1927, 83, 343.)

RAYMOND SYLVESTER PECK

Raymond Sylvester Peck was born at Ridgetown, Ontario, Canada, on February 2, 1886. He was one of the six children of Mr. and Mrs. W. R. Peck, the former a well known hotel man in that district. He was a member of one of the oldest and best known families in the southwestern section of Ontario.

At an early age his family moved to Chatham, Ontario, where Raymond Peck was educated in the public and high schools. On

graduation from his studies he commenced his career as a journalist with the old Windsor *Times* which is now the *Border Cities Star*. With this paper he rose to the post of City Editor and later removed to Detroit, Michigan, where he became associated with the editorial staff of the *Detroit Free Press*. After some years with this paper he entered the advertising field and became connected with the Nash Motor Company at Kenosha, Wisconsin, in this capacity later moving to the southern States for this concern.



In 1918 he returned to Canada to become publicity director of the Canadian Universal Film Company with headquarters at Toronto and later editor of the *Motion Picture Digest*, Canada's foremost motion picture trade paper.

In 1919 he was appointed to the Governmental Service as Film Editor of the Exhibits and Publicity Branch of the Federal Department of Trade and Commerce in Ottawa from which grew the Canadian Government Motion Picture Bureau. In 1920 on the retirement of B. E. Norrish from the directorship of this Bureau he was appointed to take charge of the Bureau, a position he held until his death on May 27, 1927.

In religion Mr. Peck was a Presbyterian. He was a leading member of the Windsor Lodge of the Masonic Order, an ex-official of the Ottawa Rotary Club, a leading member of the Y.M.C.A. and

other community and sporting organizations. At the time of his death he was a Governor of the S.M.P.E. He was a talented musician and was past president of the Ottawa South Community Orchestra Society.

Raymond Peck was one of the outstanding figures in the motion picture industry in Canada and well known in its circles in the United States and Europe. To him must be allotted the greatest amount of credit for having developed the Canadian Government Motion Picture Bureau from a little known and little thought of branch of the Canadian Civil Service to the largest and perhaps the best known governmental film organization in the world.

It was he who saw inestimable value of motion pictures as a means of the dissemination of information regarding Canada throughout the world as a means of advertising the country, its resources, industries and attractions, and as a means of encouraging settlers and visitors; and from his efforts grew an organization that holds today a unique and prominent place in the motion picture industry. From a purely local organization producing a few technical and advertising films each year for domestic use he developed a large film producing and distributing organization with a yearly output of millions of feet of film that are circulated throughout the world bringing Canada before the eyes of the people of all nations in the most telling way.

The late Mr. Peck took a leading part in encouraging the production of films in Canada and had much to do with interesting large American concerns in the production of films in the Dominion. He was an expert in distribution matters and his opinions were called for all over the British Empire. Several years ago his services were loaned to the British West Indies and for this section of the Empire he made a series of very fine films which have since been used to advertise these colonies.

Under the direction of the late Mr. Peck the Bureau developed from a practical nonentity that was an expense to the Canadian people with little return, to a large and efficient organization which in the past few years has more than paid its own way, its revenue more than defraying the cost of its operation while doing incalculable good in spreading the story of Canada and its opportunities and attractions throughout the civilized world.

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LIGHT FILTERS, THEIR CHARACTERISTICS AND APPLICATIONS IN PHOTOGRAPHY

BY LOYD A. JONES*

Outline

- I Introduction
- II Fundamental Laws:
 - A Reflection
 - B Absorption
 - C Transmission
- III Measurement, Graph Curves, Computations
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 - A Integral method
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- V Use of light filters with panchromatic film:
 - A Orthochromatic reproduction of brightness:
 - Theoretical
 - Practical
 - B Distorted reproduction of brightness:
 - General rules for enhancement of depression
 - Direction of distortion
 - Magnitude of distortion.

IN A previous communication¹ the use of panchromatic film for motion picture purposes was discussed at some length. The fundamental principles involved in the photographic reproduction of the tonal scale, that is brightness and brightness differences, in the case of colored objects were outlined and attention called to some of the advantages arising from the use of panchromatic film for this purpose. The use of light filters was mentioned briefly but no attempt was made to deal with this subject in detail. Since a thorough understanding of the nature of light filters and their use for obtaining a desired effect is essential to the attainment of the best results in the application of panchromatic film to various problems confronting the photographic worker, it seems desirable at this time to present a somewhat more complete and detailed treatment of the subject. Believing firmly in the premise that the nearest approach to perfection in the practice of a science can be attained with greatest facility and certainty through an adequate knowledge of the theoretical aspects of the subject, the first part of this paper

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will be devoted to a discussion of some of the fundamental principles involved in the use of light filters. In the latter part the more practical phases of the subject will be dealt with and some data relative to the use of light filters will be given.

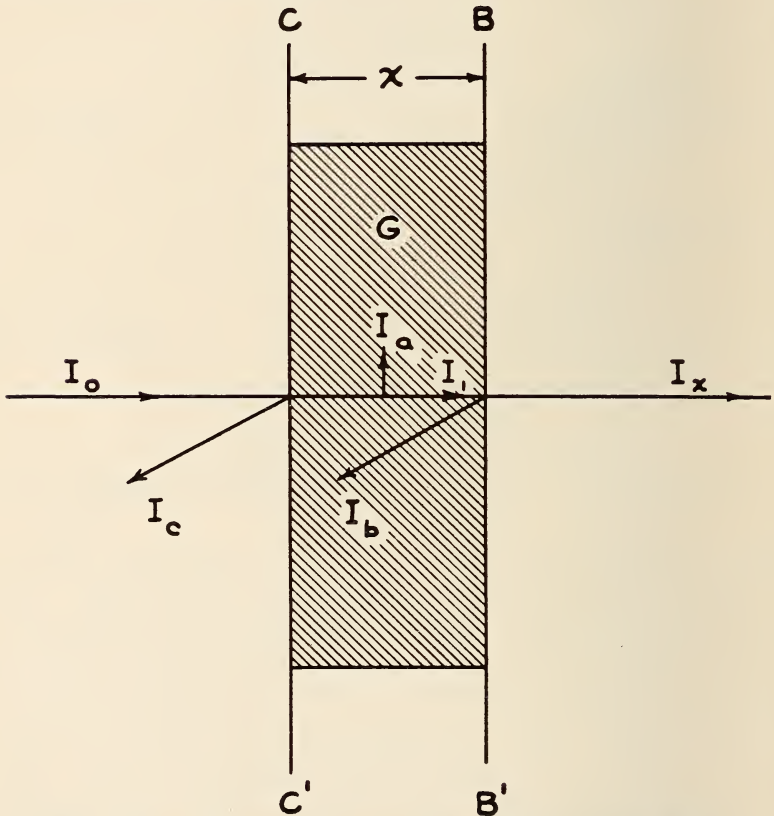


FIG. 1. Diagram illustrating reflection, absorption and transmission.

Fundamental Laws

When radiation falls upon a transmitting material, such as a piece of glass, a part is *reflected* at the first surface, some is *absorbed* within the material, some is *reflected* at the second surface, and the remainder is *transmitted*. In case the material is not optically homogeneous or contains particles of matter of refractive index differing from that of the material itself, some of the light after entering the material will be reflected, refracted, or diffracted, and emerge either

through the front or rear surface of both as *scattered* or *diffused* light. Such a material is said to be *turbid* or *diffusing*. Opal glass and the developed photographic image, which consists of particles of metallic silver embedded in a matrix of gelatine, are typical examples of diffusing materials. Diffusing materials are not in general suitable for photographic light filters and hence this paper will deal only with materials of the optically homogeneous non-diffusing type.

This case is illustrated schematically in Fig. 1 where the shaded area G represents a cross section through a transmitting material of thickness, x , and refractive index, n , bounded by the plane parallel surfaces CC' and BB' .

Let I_0 = the intensity of the incident radiation

I_c = the intensity of radiation reflected at the first surface, CC'

I_a = the intensity of the absorbed radiation

I_1 = the intensity of radiation incident on the second surface, BB'

I_b = the intensity of radiation reflected at the second surface, BB'

I_x = the intensity of the transmitted radiation.

The transmission, T , of the filter may be expressed in terms of I_0 and I_1 by the expression

$$T = \frac{I_1}{I_0} \quad (1)$$

The opacity, O , is given by the relation,

$$O = 1/T \quad (2)$$

The optical density, D , is defined by the relation,

$$D = \log_{10} O = \log_{10} \frac{1}{T} = \log_{10} \frac{I_0}{I_1} \quad (3)$$

Surface Reflection. The intensity of the radiation reflected at the boundary surface between two media differing in refractive index may be computed by means of the *Fresnel law* of reflection,

$$R_c = \frac{I_c}{I_0} = \frac{1 \sin^2(i-r)}{2 \sin^2(i+r)} + \frac{1 \tan^2(i-r)}{2 \tan^2(i+r)} \quad (4)$$

in which i is the angle at which the radiation is incident upon the surface, and r denotes the angle of refraction. This general form may be simplified in case the radiation is incident *normal* to the surface,

$$R_c = \frac{I_c}{I_0} = \left(\frac{n-1}{n+1} \right)^2, \quad (5)$$

in which n is the refractive index of the material and is defined by the ratio

$$n = \frac{\sin i}{\sin r} \quad (6)$$

In the case of light filters as used in photography the departure from normal incidence is so little that no appreciable error results from the use of equation (5). The value of n , the refractive index, depends upon the wave-length of the radiation, hence R_c also depends upon wave-length. The variation of n with wave-length in the case of glass and gelatine, the materials commonly used for light filters, is so small as to be of little practical significance. Assuming that the wave-length range of interest in photographic work extends from 350 $m\mu$ (the shortest wave-length transmitted by the glass of which photographic objectives are made) to 800 $m\mu$ (the longest wave-length to which photographic materials are sensitive) the variation in n for ordinary crown glass is from 1.535 (wave-length = 350 $m\mu$) to 1.511 (wave-length = 800 $m\mu$). This variation is less than 2 per cent, and since I_c is approximately 4 per cent of I_0 it is evident that the variation with wave-length of the intensity of the radiation transmitted by the surface is for all practical purposes negligible. For dry gelatine the variation of n with wave-length is of the same order of magnitude and hence for all practical purposes the use of equation (4) will give results of sufficient precision. By substituting in (4) the numerical values applying to ordinary crown glass we obtain,

$$I_c = I_0 \left(\frac{1.519 - 1}{1.519 + 1} \right)^2 = I_0 \times .0425 = 4.25\% \text{ of } I_0.$$

Assuming now that the absorption, I_a , of the material is negligibly small, this being true for visible wave-lengths in the case of thin layers of colorless glass or clear sheet gelatine, I_1 becomes equal to $I_0 - I_c$. Equation (4) may again be used for computing the reflection at the second surface, BB' . This takes the form

$$R_b = \frac{I_b}{I_1} = \left(\frac{n - 1}{n + 1} \right)^2.$$

Using the numerical values for glass and solving it is found that

$$\begin{aligned} I_b &= 0.0404 I_0 \\ I_x &= I_0 - (I_c + I_b) \end{aligned} \quad (7)$$

Placing I_0 equal to unity we obtain

$$\begin{aligned} I_x &= 1.0 - (0.0425 \times .0404) \\ &= 1.0 - 0.083 = .917. \end{aligned}$$

It is evident therefore that the maximum intensity of any wavelength that can be transmitted through a filter having two glass air surfaces is only 91.7 per cent of the incident intensity. This 8 per cent (approximate) loss resulting from the use of a single layer of glass or gelatine, since the refractive index of gelatine is practically equal to that of glass, is not as a rule serious, but if an attempt is made to obtain some desired result by use of two or more layers, the loss of intensity due to this reflection at the glass air or gelatine air surface may become serious. In computing the loss due to surface reflection in the case of two or more superposed layers of gelatine or glass, the rather laborious step by step method illustrated above may be avoided by use of the equation,

$$T_p = T_1^p \quad (8)$$

in which T_1 is the transmission of a single surface, p denotes the number of surfaces involved, and T_p is the transmission for p surfaces. In terms of the notation used in this paper,

$$T_1 = \frac{I_1}{I_0}.$$

For convenience in computing this equation may be expressed in logarithmic form,

$$\log T_p = p(\log I_1 - \log I_0).$$

In this treatment of the surface reflection losses no mention has been made of the multiple inter-facial reflections. The equation covering the case of multiple reflections takes the form of an infinite series. The magnitude of the successive terms of this series decreases so rapidly, even the second term being negligibly small, that the above form is entirely satisfactory for practical purposes.

Absorption of Radiation. The absorption which occurs within a non-turbid transmitting material follows a logarithmic law in all cases, including gases, liquids, and solids. Thus if a given layer of material absorbs a certain fraction of the radiation the next layer of the same thickness will absorb the same fraction of that transmitted by the first. If each layer of unit thickness transmits a fraction T (or absorbs $1 - T$) then a layer of thickness x will transmit a fraction

T^z . This may be expressed in the form of *Bouguer's law*,²

$$I_x = I_0 e^{-ax} \quad (9)$$

where I_x is the intensity of the radiation transmitted by a layer whose thickness is x , a is a constant referred to as the *absorption constant*, and e is the base of natural logarithms. This form is convenient for application to the cases of absorption by gases, liquids (not solutions), and solids, such as transparent or colored glasses in which the required variation of absorption characteristics is controlled by the thickness, x .

In dealing with the solutions it is more convenient to use a somewhat modified form which is,

$$I_x = I_0 e^{-cx} \quad (10)$$

in which c is the concentration of the solute in grams per unit volume, and x again denotes the thickness of the absorbing layer.

A third form is particularly adapted to the case of dyed gelatine filters.

$$I_x = I_0 e^{-axc} \quad (11)$$

in which c is the dye concentration expressed in grams per unit area; x the thickness factor, being implicitly included in c .

It is known that some dyes in solution do not obey *Bouguer's law* but thus far³ no observations have been made which indicate a departure of dyed gelatine filters from equation (11). Results reported by Von Hübl⁴ indicate that many dyes which in water solution depart from *Bouguer's law* follow precisely the form shown in equation (11) when incorporated in dry gelatine.

Measurements, Graphic Representation, and Computation

The absorption constant, a , is in general dependent upon the wave-length [$a=f(\lambda)$] and the determination of the value of a for various wave-lengths provides adequate information relative to the absorbing characteristics of light filters. In theoretical work on dyes and in the manufacture of filters these values of a express the relation between wave-length and absorption in a form directly applicable to the problems involved, but in the more practical application of filters to photographic problems it is usually more convenient to express the relationship between absorption or transmission and wave-length in a somewhat different form.

To determine quantitatively the absorption of a light filter for radiation of different wave-lengths a spectrophotometer is used. An essential element of this instrument is a device, such as a prism or diffraction grating, for dispersing or separating into its component parts the radiation from some suitable source (such as the electric arc or incandescent lamp) which emits many different wave-lengths. In this way a spectrum is formed and by means of a narrow slit suitably placed, radiation of any desired wave-length may be isolated. One-half of this *monochromatic* radiation is then allowed to fall upon

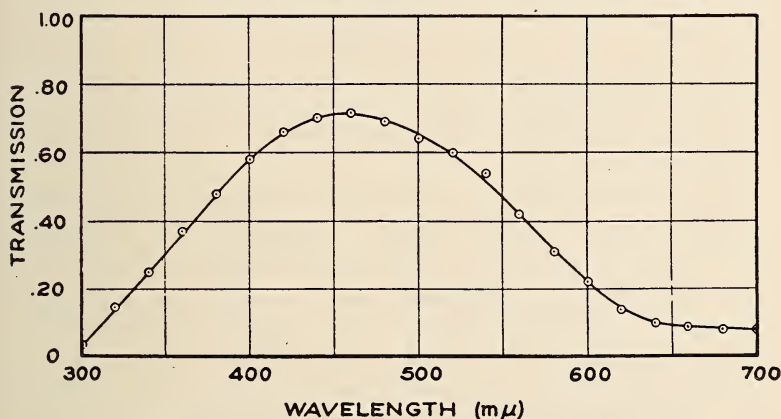


FIG. 2. Spectrophotometric transmission curve of green filter.

the filter being examined and the intensity of the radiation transmitted by the filter is measured by comparing it in a suitable photometer with the other half of the monochromatic beam which has not been subjected to the absorbing action of the filter. In this way values of transmission, T , where

$$T = \frac{I_x}{I_0} \quad (\text{see Fig. 1}),$$

for a series of different wave-lengths are obtained. These values plotted as a function of wave-length give a curve which shows the absorption characteristics of the filter in graphic form. This is called a *spectrophotometric curve*. It is customary in plotting such a curve to multiply I_x/I_0 by 100, thus expressing transmission in percentage. Such a curve is shown in Fig. 2, applying to a gelatine filter made by the use of toluidine blue.

For many purposes the expression of absorption in terms of optical density, equation (3), is more convenient than in terms

of transmission. If it is desired to compute the spectral distribution of absorption for two superposed filters, the *transmission* values at each wave-length for the two filters must be *multiplied* together, while if *density* is used it is only necessary to *add* the values at corresponding wave-lengths. Moreover since,

$$\begin{aligned} D &= \log \frac{1}{T} \\ &= -\log T \\ &= -\log \frac{I_x}{I_0} \end{aligned}$$

it is evident by comparison with equations (9), (10), and (11) expressing *Bouguer's law* that:

(a) In case of solids, liquids, and gases *D* is directly proportional to the thickness, *x*.

(b) In case of solutions *D* is directly proportional to the product of concentration, *c*, (grams per unit volume) by the thickness, *x*. Hence if *x* is constant *D* is directly proportional to *c* and if *c* is constant, *D* is directly proportional to *x*.

(c) In case of dyed gelatine *D* is directly proportional to *c* (grams per unit area).

This direct proportionality of *D* to the various exponents in the Bouguer equations of course applies only to the value of *D* after correction for surface reflection. Density as computed from transmission measurements made in the usual manner include the intensity losses due to surface reflections. It is evident that the surface reflection factor is entirely independent of the concentration and thickness factors. The correction for surface reflection is easily made provided the refractive index is known. Thus for glass or gelatine the reflection loss for the two surfaces is approximately 8 per cent, or 0.08, corresponding to a transmission of 0.92. This is independent of wave-length and equivalent to a density of ($D = \log \frac{1}{0.92}$)0.036. Hence by subtracting .036 from all density values the density due to absorption is obtained. These values are now directly proportional to the thickness or concentrations as indicated in the Bouguer equations. Having determined these densities due to absorption at any wave-length for one thickness, *x*, or concentration, *c*, the density due to absorption for any other concentration, *c'*, or thickness, *x'*, can be computed by the simple procedure of multiplication.

In Fig. 3, curve *A*, the spectrophotometric density curve for the filter illustrated in Fig. 2 is shown. Now suppose it is desired to determine the effect upon the spectral absorption of increased concentration of dye used in making the filter. Let the required concentrations be 2 and 4 times that represented by curve *A* in which it may be assumed that concentration is x grams per unit area. Let D_λ be the density at some particular wave-length λ as read

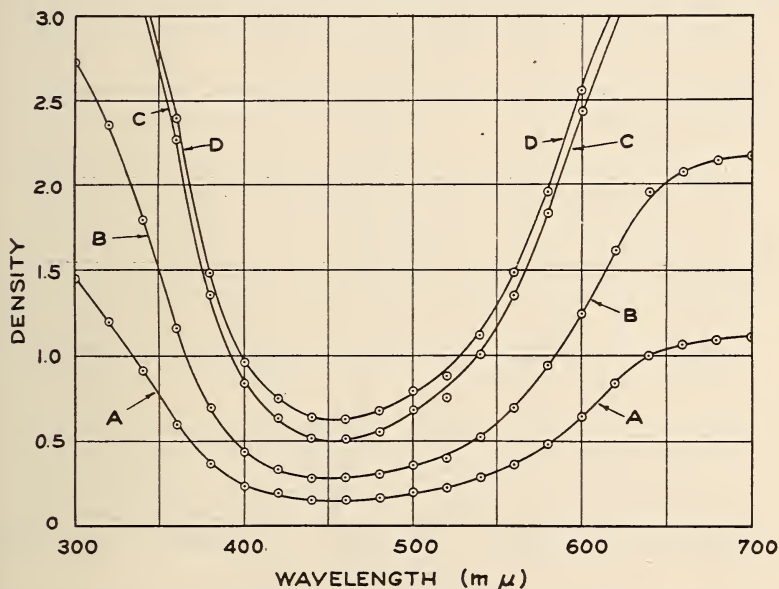


FIG. 3. Spectrophotometric density curves of green filter, illustrating relation between density and concentration and effect of surface reflection.

from curve *A*, for concentration $2x$ the required density will be given by

$$D'_\lambda = [(D_\lambda - .036)2] + 0.036$$

and for a concentration of $4x$

$$D''_\lambda = [(D_\lambda - .036)4] + 0.036.$$

Computing the necessary values for various wave-lengths and plotting, the curves *B* and *C* are obtained. It is interesting to compare the result obtained by increasing the concentration 4 times, curve *C*, with that obtained by using four layers of the original film as shown by curve *A*. This case is represented by curve *D*, the ordinates of which were obtained by multiplying the ordinates of curve *A* by 4.

It will be noted that the minimum density of curve *C* is appreciably less than that of curve *D*, thus the transmission of filter *C* for the wave-length which it transmits most freely is greater than that of filter *D*. The filter obtained by increasing the concentration four times is therefore more efficient from the standpoint of high selectivity in absorption characteristics than that obtained by using four layers of film.

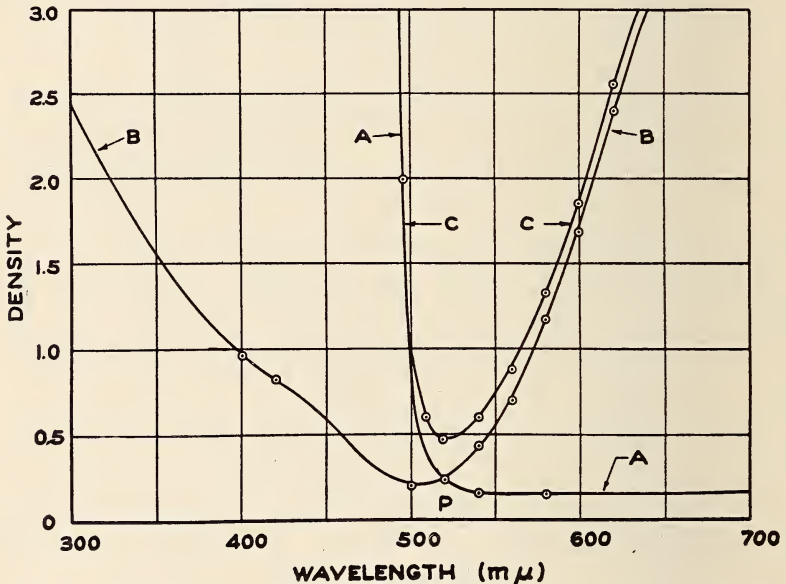


FIG. 4. Spectrophotometric density curves of *A* red filter, *B* green filter, and *C* the green filter obtained by superposing *A* and *B*.

The expression of the data in the form of density is also most convenient where it is desired to compute the spectral absorption obtainable by the superposition of two or more filters or the use of two or more dyes in the same solution or gelatine film. In the case of the superposition of the two sheets of dyed gelatine or pieces of glass it is only necessary to add at each wave-length the density values as determined directly by the spectrophotometer in terms of I_0 and I_x . In case the addition is to be made by incorporating two dyes in the same solution or in the same sheet of gelatine it is apparent that the appropriate correction must be made for any surface reflection factor which may be included in the density values for the individual dye components. In Fig. 4, curve *A*, is shown the spectro-

photometric density curve of a yellow (blue absorbing) gelatine filter. Curve *B* shows the same characteristic for a blue-green (red absorbing) gelatine filter. Curve *C* is that obtained by adding the ordinates of *A* and *B* and shows the spectral absorption obtained by the superposition of one layer of each filter. Curves *A* and *B* intersect at the point *p* of which the density value is 0.25 (transmission = 56.4%). The density of the superposed combination, curve *C*, at the corresponding wave-length is two times 0.25 or 0.50

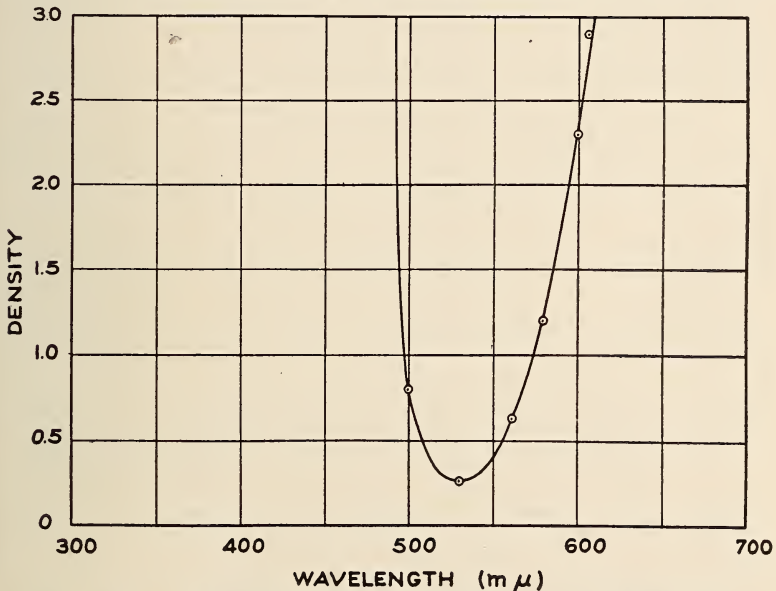


FIG. 5. Spectrophotometric density curve of "sharp cut" green filter.

(transmission = 32%). This is the minimum density value of *C*. Hence at the wave-length which is transmitted most freely by the combination only 32 per cent of the incident radiation is transmitted. This compound filter (curve *C*) is bright green in color and isolates fairly well the wave-length band from 500 to 600 mμ. A filter of much greater efficiency for this purpose can be made by incorporating properly selected dyes in a gelatine film. Such a filter is illustrated by the curve in Fig. 5. This has maximum transmission at approximately the same wave-length as *C* (Fig. 4) this being 54 per cent ($D=0.25$), almost twice that of filter *C*.

A similar low efficiency is usually encountered to a greater or lesser extent whenever an attempt is made to isolate some particular

spectral region by superposing two or more separate filters. This is due in part to the increasing loss in surface reflections as the number of separate filters is increased. Furthermore each filter is designed by the manufacturer to give some specific spectral absorption with maximum efficiency and to this end the best possible available dyes are selected. If some entirely different spectral absorption is required it is probable that dyes can be selected which will function

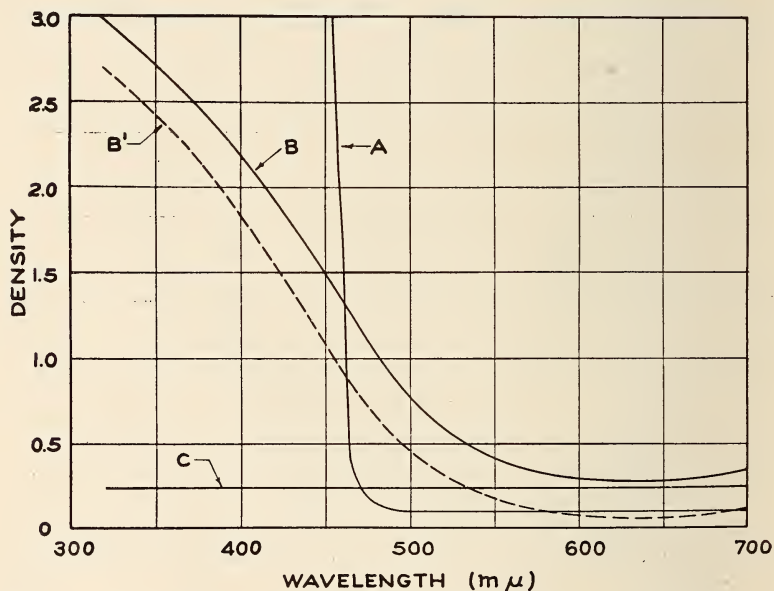


FIG. 6. Spectrophotometric curves illustrating "sharp cut" A, gradual cut "inefficient" filter B, and gradual cut efficient filter B'.

with greater efficiency than can be obtained by combining two filters designed specifically to meet other requirements.

The terms "sharp cut" and "gradual cut" are frequently applied as descriptive of light filters. The significance of these terms may be illustrated by reference to Fig. 6. Curve A is the spectrophotometric curve of a brilliant yellow gelatine filter. Its density at all wavelengths greater than 480 mμ is 0.1 (transmission = 86%). The absorption at wave-lengths less than 480 mμ increases rapidly so that at 460 mμ its density is 1.5 (transmission = 3.1%). Such a filter is described as a "sharp cut" filter. It is evident therefore that the term "sharp cut" applies to a filter of which the absorption curve is steep, that is the rate of change of absorption with variation in wave-length

is great, or conversely the condition described as "sharp cut" applies to the case where a relatively small change in wave-length is accompanied by a large change in absorption.

Curve *B* applies to a piece of *amber* glass and to such a filter the descriptive term "gradual cut" is applied. It will be noted that the wave-length band over which the change from its minimum to maximum density occurs is very broad, extending from 600 $m\mu$ to 300 $m\mu$. The slope of the absorption curve in this region of variable absorption is low and hence the filter is described as one having a "gradual cut." The transmission of this filter for the wave-length it transmits most freely is very low, being approximately 50 per cent (density = 0.3) in the region from 600 to 800 $m\mu$. Filter *A* has a bright yellow color, while *B* has a hue slightly more orange and exhibits a dull "muddy" appearance. This term "muddy" is also used frequently as descriptive of light filters and indicates a relatively high general absorption for all wave-lengths in the visible region. The muddy appearance may be considered as due to an admixture of black in the filter. For instance let the dotted curve *B'* represent a filter having an absorption curve similar in shape to that of *B* but for which the density at all wave-lengths is .24 less than that of *B*. The maximum transmission of *B'*, in the wave-length band from 600 to 690 $m\mu$, is 90 per cent and such a filter has a clean brilliant appearance although the dominant wave-length is somewhat longer than in the case of filter *A* thus giving filter *B'* a hue which is more orange. Now suppose that to this filter (curve *B'*) is added a black dye, represented by curve *C* of such concentration as to give a density of 0.24 at all wave-lengths. The addition of *C* to *B'* gives *B*, and the *B'* filter is changed thereby from a clear brilliant yellow-orange to a dull "muddy" amber. "Muddiness" in a filter is therefore due to something equivalent to the addition of a black component and is an indication of high absorption in the wave-length region of maximum transmission and hence of low optical efficiency.

Filter Factor

When a filter which absorbs some of the radiation to which the photographic material is sensitive is placed over the lens of the camera, it is evident that an increase either in exposure time, in the lens aperture, or in the illumination incident on the object, must be made in order to obtain the same exposure on the negative as when no filter is used. If any two of these factors are constant then the ratio

of the third factor as required when using the filter, to the same factor without a filter is called the *filter factor* or the *multiplying factor* of the filter. This will be designated by the symbol F . An "eight times" filter is one for which the multiplying factor is 8, etc.

The magnitude of the *filter factor* depends on the conditions under which the filter is used and its determination involves a knowledge of the spectral sensitivity of the photographic material, the spectral distribution of energy in the radiation which illuminates

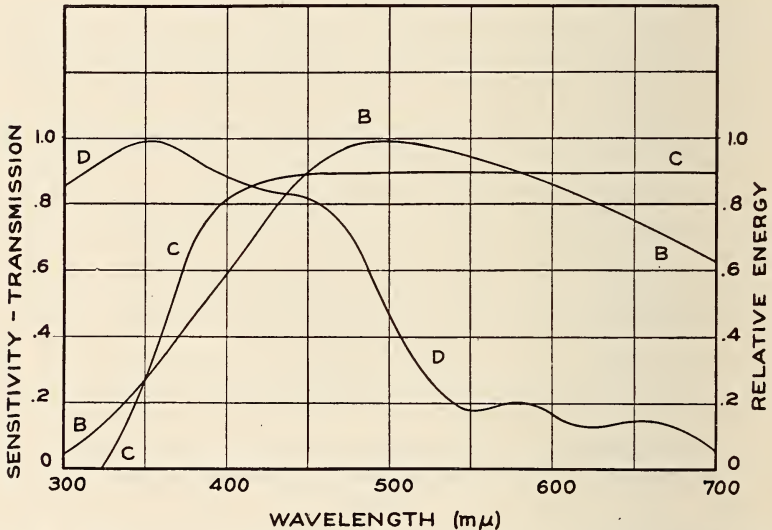


FIG. 7. Spectrophotometric curves showing the relation between photographic sensitivity, D , energy distribution in daylight, B , and transmission of radiation by photographic objective, C .

the object, and the spectral absorption of all components of the optical system between the object and the photographic material. In Fig. 7 these various characteristics are shown in graphic form.

Let the sensitivity of the photographic material be designated by the symbol A . Curve D shows the spectral distribution of sensitivity for panchromatic motion picture negative film and may be represented formally by

$$A = f(\lambda) \quad (14)$$

At any particular wave-length, λ , the ordinate of this curve will be represented by the symbol A_λ . Sensitivity, A , may be expressed in several different forms depending upon the problem to which the data are to be applied. For our present purpose it seems most logical

to define sensitivity as directly proportional to the density which is produced for a fixed development time by the action of a constant amount of energy (ergs per cm. sq.) of the various wave-lengths as indicated by the scale established on the X-axis. Curve *D* in Fig. 7 represents the spectral distribution of sensitivity as defined in this manner.

The spectral distribution of energy in *daylight* is shown by curve *B* which may be represented formally by,

$$J = f(\lambda) \quad (15)$$

The ordinate of this curve at any wave-length, λ , will be represented by the symbol J_λ . The curve as shown is computed from the data given in the previous communication¹ (Fig. 7, p. 144). Measurements have shown that of the radiation incident on a horizontal plane so placed as to receive radiation from the entire sky hemisphere and from the sun, 80 per cent is *sunlight* and 20 per cent *skylight*. Using the curves representing the distribution of energy in radiation from sun and sky and combining these in the proportion 80–20 the curve *B* in Fig. 7 is obtained. On a vertical plane exposed to sunlight the percentage of skylight is probably only about 10 per cent, but in the shadows a much greater proportion of the radiation is due to skylight so that the above ratio (80–20) is thought to represent a very probable composition of the average quality of natural illumination effective in photography. The curve as plotted shows only relative energy values, the maximum ordinate being arbitrarily adjusted to unity (1.0). It is not necessary in this case to use absolute values since we are interested only in determining the *ratio* of the filter exposure to the no-filter exposure.

In practical work the only other absorbing material of importance between the photographic plate and the object is the lens. This is usually made of three or more pieces of optical glass which may or may not be cemented together with a thin layer of Canada balsam. The absorption of energy by this lens in the visible region is relatively small and constant but in the ultraviolet, wave-length less than 400, the absorption is variable and becomes large as wave-length decreases. The lens, therefore, has an appreciable influence upon the spectral composition of radiation which reaches the photographic material. The spectrophotometric transmission curve of a typical motion picture objective is shown in curve *C*. This curve may be represented formally by

$$T = f(\lambda) \quad (16)$$

The ordinate of this curve at any particular wave-length, λ , will be represented by T_λ .

Now the relative intensity of radiation of any particular wave-length which reaches the photographic material is proportional to the product of the ordinates of the curves *B*, *C*, and *D*. Multiplying through at each wave-length and plotting the result as a function of

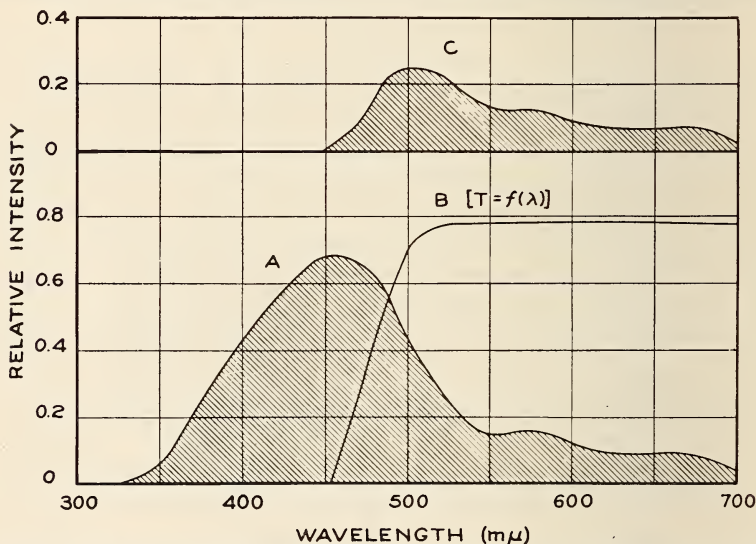


FIG. 8. Curves illustrating the determination of filter factor by integration method.

wave-length, curve *A* in Fig. 8 is obtained. The total photographic effect produced on the sensitive material is directly proportional to the shaded area enclosed between the curve and the X-axis. The magnitude of this area, *P*, can be expressed analytically by the integral

$$P = \int_0^{\infty} A_\lambda T_\lambda J_\lambda d\lambda \quad (17)$$

The area *P* as given by equation (17) can be determined by mechanical integration using a suitable planimeter. As a matter of fact it is necessary to do this since in general it is impossible to evaluate analytically equations (14), (15), and (16). By using the planimeter the area under curve *A* shown in Fig. 8 was found to be $0.76 \times a$.

Now suppose that a filter is to be used and let the transmission function of this filter be represented by curve *B* (Fig. 8), expressed by,

$$T' = f(\lambda) \quad (18)$$

the ordinate of which at any wave-length, λ , is T'_λ . By multiplying ordinates of curve *A* by those of curve *B* at corresponding wave-lengths the spectral distribution of the energy reaching the photographic plate when the filter is used can be obtained. Curve *C* at the top of Fig. 8 was obtained in this manner. The ordinate of this curve at any wave-length, λ , is

$$T'_\lambda = J_\lambda A_\lambda T_\lambda T'_\lambda.$$

The total photographic effect produced on the sensitive material is directly proportional to the area enclosed under curve *C*, this being represented by the shaded area in the figure. This area, *Q*, is represented analytically by the expression

$$Q = \int_0^\infty A_\lambda T_\lambda J_\lambda T'_\lambda D_\lambda.$$

By using the planimeter the magnitude of this area can be determined. In this case *Q* was found to be $0.23 \times a$

Now the filter factor is given by the ratio of *P*, the area enclosed by curve *A*, to *Q*, the area enclosed by curve *C*. Expressed formally this is

$$F = \frac{P}{Q} = \frac{\int_0^\infty A_\lambda T_\lambda J_\lambda d\lambda}{\int_0^\infty A_\lambda T_\lambda J_\lambda T'_\lambda d\lambda}.$$

Inserting in this the values of *P* and *Q* which we have obtained by use of the planimeter it is found that

$$F = \frac{0.76a}{0.23a} = 3.3.$$

The treatment of this method of computing the filter factor involving a consideration of the spectral distribution of energy in the illuminant, spectral sensitivity of the material, and spectral transmission of the filter, illustrates forcibly the dependence of the filter factor upon existing conditions. It is obvious from an exami-

nation of Fig. 7 if curve *B*, which represents the distribution of energy in daylight, be replaced by the curve representing the distribution of energy in some other source, such as the tungsten incandescent lamp, that curve *A* would have a very different form. The maximum will be at a much greater wave-length and all of the ordinates in the region between 500 and 700 $m\mu$ will be appreciably greater than in case of curve *A*. It is also evident that by multiplying the ordinates of curve *B* by this new curve, which we may refer to as *A'*, the curve

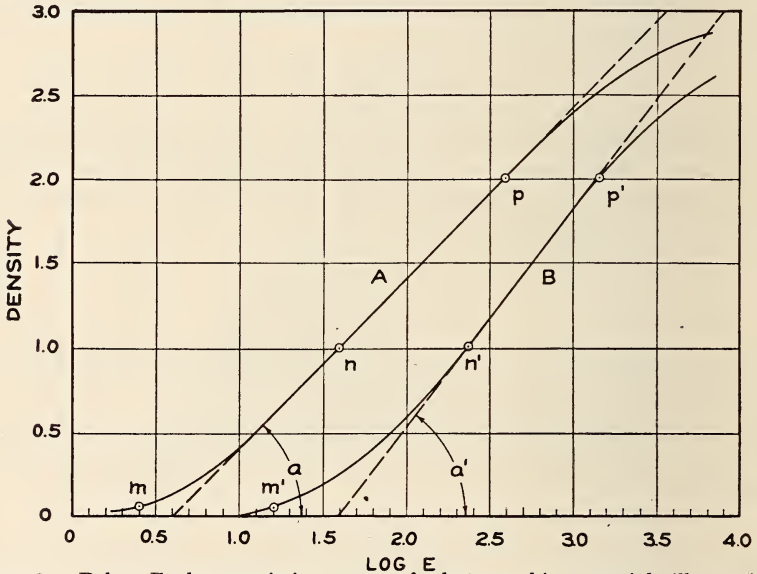


FIG. 9. D-log *E* characteristic curves of photographic material illustrating dependence of gamma on wave-length.

C' thus established will enclose a much greater area than the curve shown (*C*). The ratio of the areas enclosed under these new curves, *A'* and *C'*, therefore will be appreciably less than obtained for the daylight illumination condition. Therefore for a yellow filter such as is represented by the curve *B* the multiplying factor when used on panchromatic motion picture negative film in tungsten illumination will be appreciably less than under conditions of daylight illumination.

As stated previously this method of treatment is particularly adapted to an understanding of why the filter factor depends upon the light source and photographic material. In practice filter factors are determined in a very different manner by a direct sensitometric method. It may be well to discuss this briefly since it will also illus-

trate one other condition which must be considered in the specification of a filter factor.

The density-log exposure characteristic, frequently referred to as the *Hurter and Driffield (H & D) curve*, is obtained by exposing a sample of the photographic material in a suitable sensitometer, developing, measuring the *density* of the resulting silver deposits, and plotting these densities as a function of log exposure. The multiplying factor of a filter may be obtained by making two such sensitometric exposures, one with the filter placed between the light source and the photographic material and the other with the filter removed. The curves in Fig. 9 illustrate the results obtained in this manner, curve *A* being the density-log *E* characteristic obtained without the filter, and *B* that with the filter in position. Both curves are plotted to the same log *E* scale, the exposure (*I.t*) values being those incident on the photographic material *without* the filter in position. It is customary in sensitometry to illuminate the photographic material with light equivalent in spectral composition to *noon sunlight*, this being at present the most satisfactory specification of *standard white light*. Curve *A* therefore gives the effective characteristic of the material when used in the camera for reproduction of a *neutral tone* series extending from black through the gray series to white. Curve *A* is called the *white light characteristic*. Curve *B* was obtained by exposing through a deep red filter and is called the *red characteristic*. The exposed films from which these two curves were obtained were developed together under exactly the same conditions as regards development time and concentration of developer. It will be noted that the slope of the straight line portion, which is expressed in terms of gamma ($\gamma = \tan a$), of *B* is appreciably greater than that of *A*. This indicates that the contrast (γ) to which a photographic material develops under fixed conditions is not in general independent of the wave-length of radiation to which it is exposed. In the case of panchromatic materials the contrast resulting from exposure through a blue, green, and red filter may or may not be different from that obtained by exposure without a filter. Since there is a great preponderance of sensitivity to radiation in the wave-length region from 380 to 480 $m\mu$, the gamma of the characteristic curve determined from exposures made through the blue filter is in general almost identical to that of the white light curve, although the blue gamma may frequently be somewhat less (5 or 10 per cent) than that obtained by exposure to white light. The green

gamma is usually somewhat greater than the white light gamma. The difference is usually found to be of the order of 10 to 15 per cent. The red gamma is also on the average greater than the white light gamma, by approximately the same amount as that found in the case of the green. Furthermore the curves obtained by exposure to different qualities of radiation may differ from each other in *general shape* quite apart from the differences in *slope* already noted. Thus the under-exposure region may be shorter and steeper in one case than in another and differences in the curvature of the over-exposure region may also exist. These differences in shape and slope, resulting from variations in the spectral composition of the exposing radiation make it difficult to define a standard method for computing filter factor.

It is customary to express the *speed* of a photographic material in terms of *inertia*, i , which is defined as the exposure, E , at the point where the straight line extended cuts the $\log E$ axis, these points for the *white light* (A) and *red* (B) curves being indicated as i and i' respectively. Speed (S) is inversely proportional to these values and hence is defined as,

$$S = \frac{1}{i} k,$$

k being constant. Now the multiplying factor may be computed from these values of inertia, i , by the expression

$$K_i = i'/i.$$

In this case,

$$\log i = 0.6, \quad i = 4.0$$

$$\log i' = 1.6, \quad i' = 40.0.$$

Hence,

$$K_i = 40/4 = 10.$$

Now a negative made using $K = 10$ will match in density the no-filter negative at some point in the shadow region, but the filter negative will have greater density in the half-tone and high-light regions.

By locating the points p and p' on the two curves where D is equal to 2.0 and computing K by using the exposure values corresponding to these points the filter negative will match the no-filter negative in the highlight region but show lower densities in the shadow and half-tones. Using this method

$$\log E \text{ (for } p) = 2.6, \quad E = 398.$$

$$\log E \text{ (for } p') = 3.16, \quad E = 1450.$$

$$K_p = 1450/398 = 3.6.$$

Likewise balance can be obtained in the half-tone region by using the E values corresponding to points n and n' located on each curve where $D = 1.00$.

$$\log E \text{ (for } n) = 1.60, \quad E = 40$$

$$\log E \text{ (for } n') = 2.38, \quad E = 240$$

$$K_n = 240/40 = 6.0.$$

Because of limitations in illumination, object brightness, permissible exposure time, etc., it is frequently necessary to utilize the under-exposure region of the characteristic curve. The expression of plate speed⁵ in terms of the exposure required to produce some limiting minimum gradient, $dD/d \log E$, seems in many respects to be a more logical procedure than that of using the inertia point. The value of minimum gradient adopted for this purpose must be determined from a consideration of tone reproduction requirements. The points m and m' , Fig. 9, are located on the characteristic curves where $dD/d \log E$ is equal to .2, these values being chosen arbitrarily for the sake of illustration. The multiplying factor may be computed in terms of the exposure values corresponding to the points m , m' and the filter negative will then match the no-filter negative in the *extreme shadow* region.

$$\log E \text{ (for } m) = 0.04, \quad E = 2.52$$

$$\log E \text{ (for } m') = 1.2, \quad E = 15.9$$

$$K_m = 15.92/2.52 = 6.3.$$

The determination of K as illustrated by the curves in Fig. 9 assumes there is no appreciable failure of the reciprocity law within the utilized intensity range. For high speed material, such as Eastman panchromatic motion picture negative and the Par and Super-Speed orthochromatic motion picture negative materials, this assumption is justifiable provided the sensitometric exposures used in determining the $\log E$ characteristics are made at illumination levels of the same order as those which exist in the case of camera exposures.

It is evident from the discussion that the choice of a method for expressing *multiplying factor* must depend on the requirements of the particular problem. It is probable that the use of exposure values corresponding to densities of 1.0 (in this case giving $K = 6.0$) most

satisfactorily meets the requirements of the great majority of cases in motion picture work. This in fact is the method usually adopted in the measurement of filter factor.

The curves in Fig. 9 also illustrate the point mentioned in the section dealing with the evaluation of filter factor by the use of the spectral sensitivity curve (Fig. 7) of the photographic material. It is evident that if spectral sensitivity be expressed in terms of reciprocal inertia values that the factor obtained will not be the same as when this function is expressed in terms, let us say, of energy per unit area required to give a fixed density of unity with normal development, white light gamma equal to 0.80. For the purpose of filter factor determination by the integration method it is necessary therefore to consider carefully the manner in which sensitivity is defined. By using sensitivity defined in terms of the reciprocal energy per unit area required to give unit density at normal development, the value of K for any filter computed by the integration method should check closely with K_n measured sensitometrically.

The case illustrated in Fig. 9 probably over-emphasizes the difficulty in the specification of multiplying factor since the curves shown represent a rather extreme case of gamma differences. The filter used in this case has a very sharp cut narrow transmission band which tends to give the maximum gamma difference. In using "gradual cut" broad transmission band filters such as are employed for obtaining orthochromatic rendering, the gamma differences encountered in using panchromatic motion picture negative film are inappreciable from the practical standpoint. Even with the tri-color filters, which are sharp cut filters transmitting wave-length bands approximately 100 $m\mu$ wide, the variation in gamma obtained with panchromatic motion picture negative film is not large for the average case. The possibility of variation in slope (γ) and shape of the D-log E characteristic due to spectral composition of the radiation transmitted by a filter and the resultant dependence of filter factor upon the region (highlight, half-tone, or shadow) in which equality of density is required should be understood and recognized by workers in the photographic field who wish to realize to the fullest extent the possibilities and limitations of the light sensitive material.

In making a photograph of an object on a specific photographic material without a filter let the magnitude of the exposure time, lens aperture, and illumination be designated as follows:

t_0 = exposure time
 S_0 = area of the lens diaphragm opening
 N_0 = illumination incident on the object.

Let the magnitude of these terms as required for obtaining an equally exposed negative when using a filter be t_a , S_a , N_a , respectively. Then:

$$F = \frac{t_a}{t_0} \cdot \frac{S_a}{S_0} \cdot \frac{N_a}{N_0} \quad (12)$$

If $S_0 = S_a$, and $N_0 = N_a$,

$$F = \frac{t_a}{t_0}, \text{ etc.}$$

Since the area of the diaphragm opening is directly proportional to the square of the *stop numbers* or *diaphragm numbers*, f , used in marking and setting the iris diaphragm, it follows that

$$\frac{S_a}{S_0} = \frac{f_a^2}{f_0^2} \quad (13)$$

Hence the value of the stop number may be substituted in (12) if desired.

The validity of (12), which states that the required compensation for the decrease of energy incident on the plate when an absorbing filter is used can be obtained by a variation of either t , S , or N , or by any combination of these terms depends upon the assumption that there is no failure of the reciprocity law within the range of intensities concerned. This law states that the photochemical action which takes place when radiation acts upon a photographic material is directly proportional to the product of radiation intensity, I , by the time, t , during which it acts and is independent of the absolute value of either factor. It is probable for all conditions involved in motion picture work that this assumption is justified and that no error of sufficient magnitude to be of practical importance will result from the use of equation (12).

In motion picture work, since it is necessary to take at a fixed rate, 16 exposures per second, the t factor of exposure can be controlled only by variations in the angular opening of the camera shutter. In using a filter of relatively high factor, it may be impossible to increase t sufficiently. It will be necessary in some cases to increase the intensity factor of the exposure. This can be done by increasing either S or N , both of which control the intensity factor, I , of ex-

posure. The application of equation (12) to a specific case may be of interest.

Suppose that with I_0 equal to 4000 foot candles, f_0 equal to $f:6.3$, and t_0 equal to $1/64$ sec. (this corresponds to a shutter opening of 90° at standard taking rate of 16 pictures per second), a normally exposed negative is obtained. Suppose further that a filter for which $F=8$ is to be used. Assuming that the lens diaphragm can be opened only to $f:4.5$ without undue loss of focal depth, let it be required to determine how much the illumination on the object must be increased or decreased to obtain the same exposure on the negative.

$$\frac{t_a}{t_0} \cdot \frac{f_a^2}{f_0^2} = \frac{210}{90} \cdot \frac{6.3^2}{4.5^2} = 2.34 \times 1.96 = 4.57.$$

Since $F=8$ it is evident from equation (12) that

$$I_a = \frac{8}{4.57} \cdot I_0 = 1.75 \times 4000 = 7000 \text{ foot candles.}$$

If a lens aperture of $f:3.5$ can be tolerated,

$$\frac{t_a}{t_0} \cdot \frac{f_a^2}{f_0^2} = 2.34 \times \frac{6.3^2}{3.5^2} = 7.57$$

$$I_a = \frac{8}{7.57} \times 4000 = 4240 \text{ foot candles.}$$

Thus by using the lens operating at $f:3.5$ and the shutter at 210° the "eight times" filter may be used by increasing the illumination on the set by approximately 5 per cent.

It should always be kept in mind that the value of a *filter factor* applying to any light filter is vitally dependent upon the spectral sensitivity of a photographic material and upon the quality of the light used in illuminating the object. In using filter factors for the computation of the exposure required the worker should be sure that the value employed applies to the filter as used under the existing conditions. The mere expression of the value of *filter factor* without a definite statement as to the *photographic material* and the *quality of illumination* is quite meaningless.

Use of Light Filters with Panchromatic Films

In general a collection of objects which compose a scene to be photographed presents to the eye areas which differ in *color*. In fact

it is only by differences in one or more of the three attributes of color that objects are distinguishable from each other by the visual process. The three attributes of color are *brilliance*, *hue*, and *saturation*. In the photographic negative the visual contrast which is due to a summation of differences in one or more of these three attributes can only be reproduced by a series of silver deposits which differ from each other, so far as the eye is concerned, only in the sensation of brilliance which they produce when examined visually. Likewise the positive produced from this negative, either by projection on a screen or printing on a positive material such as a photographic paper, consists simply of areas which differ from each other only in brightness and which when observed by the eye produce visual sensations differing only in brilliance. Since it is impossible with the present photographic process to reproduce all of the attributes of color we are forced to attempt the reproduction by means of a single variable those differences which in the object may be due to the action of three independent variables. In view of this situation it seems most logical to consider first how closely the one attribute of color which is directly rendered by the photographic process, namely brilliance, can be reproduced.

The ordinary (blue-sensitive) photographic plates and films differ so widely from the human eye as regards distribution of sensitivity throughout the spectrum that it is quite impossible with them to even approach satisfactory reproduction of the brilliance factor in colored objects. These materials are almost completely insensitive to radiation of wave-length longer than $550\text{ m}\mu$. The maximum sensitivity of the human eye lies at $554\text{ m}\mu$. It is evident therefore that those colors which appear brightest to the eye will be rendered as almost black by these photographic materials.

Orthochromatic materials, by the addition of dye sensitizers to the emulsion, have been rendered sensitive to the green in addition to the blue, violet, and ultra-violet. This makes it possible to approach more closely a satisfactory reproduction of the brilliance factor by using these materials. They have, however, practically no sensitivity for wave-length longer than $600\text{ m}\mu$. Now the colors which are designated as red, orange, and yellow lie within this region and hence even with orthochromatic materials are rendered much darker than they appear on the visual tone scale. The entire group of colors designated as browns also have dominant wave-lengths within this region and when the great predominance of such colors is considered

it is evident that even orthochromatic materials must fail to render the majority of scenes with these colors in their proper tonal (brilliance) relation with respect to the scale of gray (extending from black to white through grays of all intensities) and with respect to the greens, blues, and violets.

Panchromatic materials, such as motion picture panchromatic negative film, are sensitive to all wave-lengths of visible radiation. They still possess, however, a great excess of sensitivity, as shown by curve *D* in Fig. 7, to wave-length shorter than 500 $m\mu$ and hence in general render the blue-greens, blues, and violets much too high on the visual tone scale relative to the grays and to the warm colors. To obtain correct rendering of the brightness attribute of color it is necessary therefore in some way to modify the *effective* distribution of sensitivity in such a way that it will correspond more nearly with the visual sensitivity to radiation of different wave-lengths. The correct rendering of the brilliance attribute of color is termed *orthochromatic reproduction*. As used in this sense orthochromatic (derived from Greek roots, ortho—correct, and chromatic—color) has a very different meaning than as applied to photographic materials which as a matter of fact do not give *correct* color rendering but only more nearly correct than a blue sensitive plate.

Orthochromatic reproduction may not in all cases give the most *desirable* or even the most *correct* photographic rendering of visual contrast which is dependent upon three factors, *brightness contrast*, *hue contrast*, and *saturation contrast*. Orthochromatic reproduction which means simply the correct reproduction of brightness distribution in the object must, however, be regarded as the general case of which the enhancement or depression of certain definite colors above or below their normal position in the visual brightness scale must be considered as special cases. Certainly a thorough understanding of the principles of orthochromatic reproduction is prerequisite to an intelligent use of methods for producing distorted brightness reproduction.

Orthochromatic Reproduction Theory

In order to compute the spectrophotometric absorption curve of a filter which when used with panchromatic film will give perfect orthochromatic reproduction of brightness it is only necessary to know the distribution of sensitivity for the photographic material in question and the distribution of sensitivity for the eye. These functions are shown graphically in Fig. 10, curve *C* representing the

spectral sensitivity of the photographic material and curve *D* the visibility function for the eye. Both of these are plotted with maximum ordinate equal to unity. In order to determine the spectrophotometric *transmission* function of the required filter it is only necessary to divide the ordinate of the visibility curve at any wave-length by the corresponding wave-length of the photographic sensi-

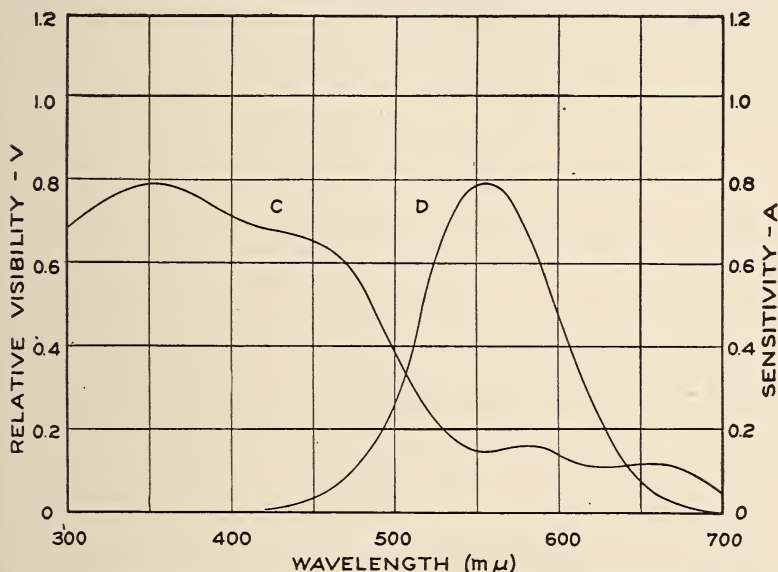


FIG. 10. Spectrophotometric curves showing spectral distribution of sensitivity, *A*; for panchromatic film, *C*; for visibility function of the eye, *D*.

tivity curve. If T_λ represents the transmission of the required filter at any wave-length its value is given by

$$T_\lambda = V_\lambda / A_\lambda.$$

Proceeding in this manner values were obtained from which the curve *A*, Fig. 11, was plotted, the scale of transmissions being shown at the left of the diagram. Converting these values to density by the usual relation, $D = \log i/T$, the spectrophotometric density characteristic of the theoretically perfect filter is shown as curve *D*. The absorption characteristic of the light filter which with a given photographic material will produce perfect orthochromatic reproduction is dependent only on the two functions shown in Fig. 10 and is independent of the spectral distribution of energy in the light source illuminating the object.

In practice it is found that a filter which produces *perfect* orthochromatic rendering is entirely too dense necessitating a prohibitively great increase in exposure time. It is customary therefore to compromise and use a filter which produces a satisfactory approach to orthochromatic rendering. The filters usually used for this purpose absorb the ultra-violet entirely and a portion of the visible spectrum in the region between 400 and 480 $m\mu$. The Wratten filters of the

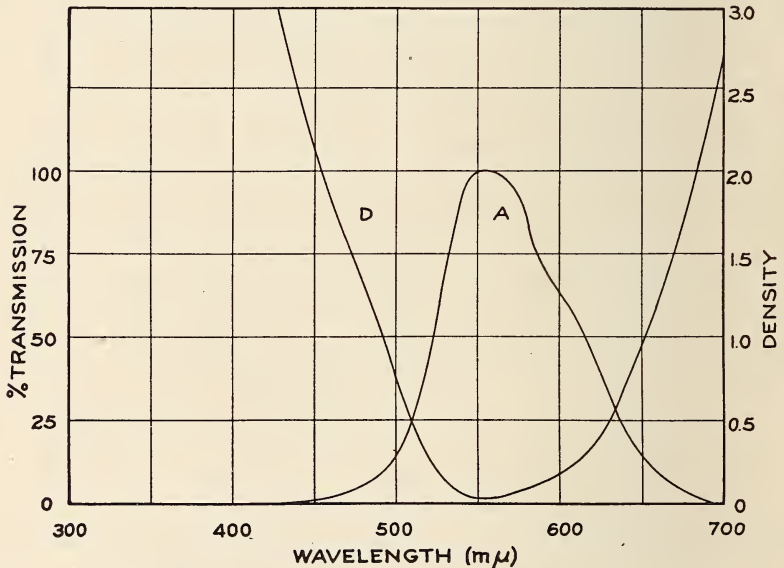


FIG. 11. Spectrophotometric density, D , and transmission, A , curves of a theoretically perfect orthochromatic filter adjusted to Eastman Panchromatic Motion Picture negative film.

K series represent typical light filters of this type. Of these the $K-2$ (Wratten No. 8) absorbs practically everything of wave-length shorter than 460 $m\mu$. This filter used with panchromatic motion picture negative produces an approximation to orthochromatic rendering and for most purposes is satisfactory from the practical standpoint.

From the theoretical standpoint the same filter (see Fig. 11) produces perfect orthochromatic rendering regardless of the spectral composition of light illuminating the set. In practice it is customary, however, to use a much lighter filter when a set is illuminated by radiation in which the longer waves predominate, such for instance

as is the case with the light emitted by tungsten incandescent lamps. This can be explained on the basis of our subjective evaluation of colors as seen under artificial illuminants. Under such conditions red and yellow objects actually appear to the eye much brighter in proportion to the gray scale and to the blues and violets than under conditions of natural illumination. Subjectively, however, they are interpreted as having the tonal value which they would have were they illuminated with white light. In using a lighter yellow filter for working with tungsten we are therefore approaching to the rendition of colored objects on the brightness scale as it would appear to the eye if the colors in question were illuminated by white light.

Distortion of Orthochromatic Reproduction

Remembering now that the total visual contrast between the colors which compose the visual field may be due either to *brilliance-contrast*, *hue-contrast*, or *saturation-contrast*, it is evident that one or two of these factors may be entirely absent leaving sufficient contrast, due to the third factor, so that objects in the field of vision may be clearly differentiated from each other. Thus it is quite possible, and as a matter of fact this frequently occurs in practice, to have two or more colored areas precisely equal in brightness (brilliance-contrast equal to zero) but clearly differentiated from each other by virtue of either hue-contrast or saturation-contrast or a combination of these two factors. Now it may be considered that the primary object in making a photograph is to reproduce the visual appearance and to show structural details of the material within the visual field. It seems therefore that the most satisfactory photographic reproduction is one which reproduces as nearly as possible the *total visual contrast* existing between the various elements of the object rather than the correct reproduction of a *single factor* upon which total visual contrast depends. If brightness-contrast is absent it is necessary to take advantage of the existing hue or saturation-contrast to obtain a photographic reproduction containing the contrast essential for the rendition of the form and detail in the object. For this purpose we have available only variations of brightness-contrast in the negative and hence we must attempt to express by means of this single variable those visual contrasts which depend upon three independent variables. Hence if two areas in the visual field are equal in brightness it is only by destroying this equality that an existing visual contrast due to hue or saturation difference can be made

manifest in the negative. Distortion of the correct reproduction of brightness values therefore is a very real necessity in some cases and by the use of light filters practically any desired distortion of this brightness scale can be obtained.

The principles involved in obtaining brightness distortion are relatively simple and once understood no difficulty should be encountered in applying them to practical problems. As a convenient starting point in this discussion let us assume a light filter and photographic material (panchromatic) giving perfect orthochromatic rendering. Now it is obvious if it is desired to render by differences in negative density two areas of different hues but of equal brightness it is only necessary to use an additional light filter which will absorb to a greater extent the radiation coming from one of the areas than it does that from the other. Furthermore, it is evident that either one of the areas can be rendered as lower or higher on the brightness scale by a proper choice of the absorbing filter. Light filters for this purpose are usually termed *contrast* filters since they are designed to enhance the photographic contrast existing between colored objects. The general rules applying to the use of contrast filters for the distortion or enhancement of brightness-contrast may be stated as follows:

To render a color at a point on the brightness scale higher (enhanced brightness) than its normal position a light filter which *selectively transmits* radiation of the wave-length corresponding to the color must be used.

To render a color at a point on the brightness scale *lower* (depressed brightness) than its normal position a light filter which *selectively absorbs* the radiation of wave-length corresponding to the color must be used.

In Table 1 the application of these two rules is shown. In the second column are shown the wave-lengths of radiation corresponding to the colors as designated in the first column. In the third column are shown the filters which must be used with each color in order to produce an enhancement of its visual brightness value. These filters are described by giving the color name applying to them and the wave-length region in which they are transmitting radiation. In the last column of the table are shown the filters which must be used to produce a depression of the brightness value of the color as indicated in the first column. It will be noted that for enhancement, the color of the filter corresponds to the color with which it must be used,

while for depression, the color of the filter is complementary to the color with which it must be used.

Filters for the depression or enhancement of brightness, contrast filters, must as a rule be fairly "sharp cut" filters in order to produce effects of sufficient magnitude. Practically all colored objects met with in practice have spectrophotometric reflection characteristics of the "gradual cut" broad absorption or reflection band type. The spectrophotometric curve of two colors which exhibit marked hue contrast, therefore, usually overlap appreciably, that is, each embraces partially the same spectral region. To produce appreciable enhancement of depression of one of these with respect to the other a filter of rather sharp cut is therefore usually required.

Direction of distortion. When two areas of equal brightness but differing in hue or saturation are to be photographed a decision must be made as to which one shall be made darker and which lighter than its normal value. It has been found by measurement and observation that those colors which reflect radiation in the region 550 to 700 $m\mu$ have in general higher reflecting powers (for the radiation which they reflect) than those which reflect radiation of wave-length shorter than 550. The former include those colors described as red, orange, yellow, and yellow-green and as a group may be referred to as the *warm* colors. The latter, violet, blue, and blue-green, are called *cool* colors. The non-spectral hues, the purples, reflect both red (600 to 700 $m\mu$) and blue-violet (400 to 500 $m\mu$). Those in which red predominates, the red-purples, are classed with the warm colors, and in general are relatively high in reflecting power. The purples in which blue predominates, the blue-purples, are classed with the cool colors and tend to have relatively low reflection factor. The best general rule to be followed in deciding the direction of distortion is to make the warm colors lighter and the cool colors darker than called for by orthochromatic rendition. This rule is based on sound psychological reasoning. Since the brightest colors of our past experience have been almost invariably those which fall in the warm classification, and the darker less brilliant ones have been found among the cool colors, in the absence of any hue or saturation factor the subconscious action of memory or stored sense impression tends toward an interpretation of the higher brightness as representing a warm color rather than the reverse.

It is interesting to note that the use of ordinary blue sensitive or orthochromatic photographic materials produces a distortion of

brightness reproduction which in many cases may tend to the conservation of the contrast between objects or colors which if rendered on panchromatic materials by orthochromatic methods would not show adequate contrast. This distortion, however, is in the wrong direction and always renders the warm colors as much darker than cool ones of equal brightness. There is little doubt that this is undesirable and that the rendition obtained with panchromatic film, with properly chosen contrast filters when necessary, will give more satisfactory results.

The photographic worker who has for many years been accustomed to using orthochromatic film frequently feels when he first uses panchromatic materials that it does not give as much contrast and may criticize the material as lacking in contrast capacity. Measurements show that panchromatic film exposed either in the sensitometer or in a camera to a neutral gray scale gives a D-log E characteristic having a slope, γ , fully as great as the Par-Speed or Super-Speed orthochromatic film. It is probable that the worker being accustomed to seeing all reds and yellows rendered as unduly dark has acquired a false conception as to the actual brightness contrast in the original. Hence the rendition obtained with panchromatic film appears to him as lacking in contrast, while as a matter of fact it may be much nearer to the true visual contrast of the object than that obtained by the distorted rendering given by orthochromatic materials.

Magnitude of distortion. Another problem which must be considered in the distortion of orthochromatic rendering is that dealing with the *magnitude* of brightness distortion required to compensate for the absence of hue and saturation contrast in the reproduction. The total visual contrast between objects differing in color may be expressed formally by the equation

$$C_t = \sum C_b, C_h, C_s$$

in which C_t = total visual contrast
 C_b = brightness contrast
 C_h = hue contrast
 C_s = saturation contrast.

In the photographic reproduction C_h and C_s are necessarily zero and it may be needful to enhance C_b in order to compensate for this absence. The sensitivity of the eye to brightness and brightness differences has been studied with great care and the formulation of

the requirements for reproducing precisely this factor is relatively simple. Unfortunately the hue and saturation characteristics of the eye have not been so carefully investigated and these functions for the average normal human eye are not at present established with certainty. No quantitative data are available which may be used to compute just what proportion of the *total visual contrast* in the case of colored objects is due to each of the three components of contrast. It is difficult to estimate therefore just how great a distortion from correct orthochromatic reproduction is necessary in any case to represent satisfactorily the hue or saturation contrast which may exist in the absence of brightness-contrast. However it seems probable that the subjective contrast between two colors differing only in hue is directly proportional to the number of least perceptible hue steps between the wave-lengths of the two hues in question. On the basis of this assumption it is evident that a blue and red of equal brightness will require a greater separation on the brightness scale to satisfy our requirement of contrast in the reproduction than, let us say, a red and a green or a red and orange which lie closer to each other on the hue scale. The same reasoning is applicable to the magnitude of brightness distortion required to compensate for the presence of saturation contrast in the absence of either hue or brightness contrast.

TABLE 1

Object		Filter to Enhance		Filter to Depress	
Color	Wave-length	Color	Transmits	Color	Absorbs
Red	600 to 700m μ	Red	600 to 700m μ	Blue-green	600 to 700m μ
Green	500 to 600	Green	500 to 600	Magenta	500 to 600
Blue	400 to 500	Blue	400 to 500	Yellow	400 to 500
Yellow	500 to 700	Yellow	500 to 700	Blue	500 to 700
Blue-green	400 to 600	Blue-green	400 to 600	Red	400 to 600
Magenta	400 to 500	Magenta	400 to 500	Green	400 to 500
	600 to 700		600 to 700		600 to 700

¹ Loyd A. Jones and J. I. Crabtree. "Panchromatic Negative Film for Motion Pictures." Trans. Soc. M. P. Eng. No. 27, 131, 1927.

² M. Bouguer. "Essai D'Optique sur la Gradation de la Lumière." Paris, 1927.

³ M. G. V. Potapenko. J. Russ. Phys. Chem. Soc. 48, 790, 1916. Brit. J. Phot. 68, 507, 1921.

⁴ A. Von Hübl. "Die Phot. Lichtfilter," 18. Halle A. S., 1910.

⁵ S. E. Sheppard. Phot. J. 66, 399, 1926.

DISCUSSION

MR. WALLER: The curve, shown in one of the slides, of the sensitivity of the panchromatic emulsion does not compare correctly with the published wedge spectrograms. Then, in the filter factor, the time of exposure and the shutter opening were given as separate things; are they not the same?

MR. JONES: These spectrograms are made in an instrument using a diffraction grating as a dispersing element so that the dispersion obtained is normal. The light source used is an unscreened acetylene burner giving radiation which is relatively strong in the longer wave-length region of the visible spectrum. As compared to daylight or sunlight the light emitted by this burner is distinctly yellow. This predominance of the longer wave-lengths produces an apparent enhancement of the red sensitivity as judged directly from the spectrograms. As regards the filter factor, the statement was an error on my part. The formula contains three factors; t_a , representing the exposure time which is determined by the shutter opening for taking speed (pictures per second), S_a the area of the lens diaphragm, and N_a the illumination on the object.

PROF. WALL: I should like to ask whether there is included in the paper data as to how the transmissions of filters, as in the Wratten Filter booklet, are obtained for each wavelength? This, I think, would be generally instructive.

MR. JONES: I have included in my paper a very brief description of spectrophotometric methods. I did not deal with this subject in detail because I feel it is a little out of place in a paper dealing essentially with the use of light filters in photography. I have not included in this paper many data on the absorption characteristics of available light filters. These data have already been published in various places. For instance Dr. Gage in a paper read before this Society some years ago gave complete spectrophotometric absorption characteristics for all of the colored glasses manufactured by the Corning Glass Company and in a booklet, Wratten Light Filters, complete data relative to the spectrophotometric characteristics of dyed gelatine filters are given. It seems quite unnecessary to duplicate these published data. I have discussed the subject rather briefly but perhaps not at sufficient length to satisfy some readers. I should like to explain that when I started to write this paper I planned to begin with the fundamentals and develop the subject logically step by step from theory to final application. After thirty-five pages of

manuscript I decided it was quite impossible to do this in one paper. I might add that we have in progress at the present time rather extensive experimental work dealing with the purely practical aspects of the photography of colored objects. We have prepared a large group of color samples and are measuring their visual reflection factors by the flicker photometer method and their photographic reflection factors by a method of photographic photometry. This is being done under various qualities of radiation such as are emitted by the sources commonly used in motion picture work and by employing photographic materials of different color sensitivity. We have chosen for this work colors of the most reproducible and stable character so that the studio worker can if he desires prepare duplicate panels. The reflection data will then show at once at what point on the visual brightness scale any particular color will be rendered. Presentation of these data has been reserved for a later paper.

MR. EGELER: Do I understand that from available data for a given illuminant and panchromatic material we can not tell just what amount of energy we should pass to create in a positive the same impressions in black and white as our eye gets? If an emulsion receives amounts of energy at different wave-lengths in direct proportion to the sensibility of the eye at different wave-lengths, would we get any impression of differences of color for the different parts of the object photographed?

MR. JONES: I feel that we can answer the first question in the affirmative. It is only recently that we have been able to do this on account of the uncertainty on the data of spectral sensitivity of photographic materials. We have just recently obtained data of this type on motion picture panchromatic film. I used this in computing the filter factor by the method described in the paper, that is by compounding the spectrophotometric characteristics concerned and then integrating the area of the resultant curves. Using this method we obtained a filter factor of 3.4 and a filter which as used in practice is commonly given a multiplying factor of 3. I consider this order of checking is quite satisfactory and well within the requirements of practice. I believe, therefore, that we are now in a position to apply these methods and to obtain results which will check satisfactorily with direct sensitometric measurements. I did not understand Mr. Egeler's second question.

MR. EGELER: In our black and white and color work we attempt to show the differences in color by differences in the degree of black

and white, such as brilliance or reflecting power. If we should attempt to show with panchromatic film these different colors appearing in the object, how can we balance them against gray so that apparently we have sensations with regard to color?

MR. JONES: In answering this question I should like to refer again to the nature of color as perceived by the eye. The total visual contrast between two objects depends on three factors: brightness difference, hue difference, and saturation difference. Now by using a theoretically perfect orthochromatic filter we can reproduce precisely on a photographic material that attribute of visual contrast which is dependent upon brightness differences. As an illustration let us assume that we have a scale of grays running from 0 to 100 per cent. in reflecting power, and in the same visual field a number of variously colored objects. Now we can measure brightness visually by means of a flicker photometer which I believe is the approved method of measuring brightness in the presence of hue differences. By using panchromatic film with a perfectly adjusted orthochromatic filter we can reproduce photographically the brightness of these variously colored objects in their proper position on the visual brightness scale as indicated by the flicker photometer values of visual brightness. This rendition we refer to as perfect orthochromatic rendering. I should like to emphasize that this rendition may not be satisfactory in all cases. For instance it is quite possible to have a red and green of equal brightness as determined by the flicker photometer measurement. These two colors when rendered orthochromatically will not be differentiated but will appear identical on the photographic plate, that is they will be rendered by the same density. Such a condition obviously is unsatisfactory and hence it may be necessary to wilfully depart from true orthochromatic reproduction and as I pointed out previously by a proper choice of light filters either one of the two colors can be rendered as lighter or darker than the other as desired. Our present knowledge of the subject is not sufficient to determine how much distortion of the correct brightness rendition is required to compensate for a visual contrast due to hue or saturation differences. We do know, however, in which direction the distortion should be made, when two colors of different hue are identical in brightness the warmer of the two should be rendered as brighter. This seems to be based on very sound theoretical reasons.

MR. BURNAP: AS I understand it, the Wratten K filter when used under daylight conditions has a factor of about $3\frac{1}{2}$. If incandescent lamp illumination be used, what factor will the filter have in that case? Does the filter factor vary with the spectral energy distribution of the light used as a source? Sunlight and incandescent lamps are quite different; how does this affect the filter?

MR. JONES: The quality of the light source does not have anything to do with the absorption characteristics of the filter required to give orthochromatic rendering. This is a point to which I have given much thought. The absorption characteristics of a filter to give orthochromatic rendering depends only on the spectral sensitivity of a photographic material and the sensitivity of the eye to radiation of various wave-lengths. It is independent of the light source used. Now this seems contradictory to what we actually do in practice since it would require that we use the same filter when working under tungsten light as we do when working outdoors under daylight illumination. As a matter of fact we do not do this but use a much lighter filter when working under tungsten illumination. In working under tungsten illumination for instance we use a filter which makes the colors of colored objects look as they should look if illuminated by daylight. This may sound somewhat impossible but I think it can be illustrated by considering the conditions which exist at present in this room illuminated as it is by tungsten lamps. The sheet of white paper which I hold before me I interpret as true white. As a matter of fact if its present appearance could be compared with its appearance under daylight illumination it would be appreciably yellow. I know by experience, however, that the paper is practically non-selective in absorbing characteristics. I therefore interpret its present appearance under the tungsten lamp as a true white or hueless color. In doing this I am influenced by knowledge gained by past experience. Similarly it seems that our requirement for the rendition of color objects when illuminated by artificial sources is that they shall be rendered on the visual tone scale in the positions which they would occupy were they illuminated by white light. At any rate in practice a lighter filter is always used when working under tungsten light than when working under daylight in order to obtain a satisfactory rendition of brightness. The reason for this procedure must lie in our stored visual impressions and in our interpretation of the relative value of colored objects in terms of white light even though we may be seeing them under illumination of different quality.

MR. BURNAP: You did not answer what the factor of the new filter would be. I think I had in the back of my mind that we think of things in daylight.

MR. JONES: A filter, such as the Wratten K-2, which has a filter factor of approximately 3, when used with panchromatic film under daylight illumination, will have a factor appreciably less when used under tungsten. The factor under tungsten would be approximately 2.0. I should like to point out again, however, that the use of such a filter under tungsten illumination will produce a rendition which we consider as over-corrected. As a matter of fact when working under tungsten illumination a very light yellow filter, such as K-1, or even no filter at all gives the most satisfactory brightness rendition of colored objects.

MR. PALMER: I should like to ask Mr. Jones to answer a question I answered for Mr. Burnap, concerning the high intensity arc as a source of illumination instead of an incandescent lamp.

MR. JONES: Judging from what I know of the spectral distribution of energy in the radiation of the high intensity arc I believe that for all practical purposes the same filter will be satisfactory as is used for daylight work. The Wratten filter K-2 should give fairly satisfactory orthochromatic rendering with the high intensity arc. By this I do not mean theoretically perfect orthochromatic rendering but a rendering which should be acceptable. As I pointed out before it is necessary to compromise to some extent since a perfect orthochromatic filter requires a rather great increase in exposure. It is apparent from a consideration of the computed curve that a perfect orthochromatic filter must absorb some in the extreme red. The absence of such absorption, however, is not serious except where the requirements are very severe. So far as can be judged by a visual inspection of the print the K-2 filter produces satisfactory results.

MR. MAYER: This may seem to be irrelevant to the subject, but is it not a fact that the cutting off is not constant? Is there not a varying degree of rendition of the waves around 3600?

MR. JONES: There is undoubtedly a difference in lenses, which I think is negligible compared with the cut-off of the K-2 filter, which cuts sharply at 440, which is so far in that the lens differences are negligible. Working without a filter, then, we might find differences in lenses which would be appreciable, but for orthochromatic rendering and the filter value given to you it is negligible.

MR. WALLER: I want to rise to a point of protest against Mr. Jones' statement of the fact that in order to correct for hue we should increase brightness as we get into the reds. I don't doubt that Mr. Jones' findings are correct scientifically; in fact, I know that they are, but another factor enters in which I think we should reason. All of us have a store of visual impressions, and as we have stored visual impressions, we have stored photographic impressions. Mr. Jones just pointed out that it is an accumulation of these impressions which makes us see the things in this room as we would see them in white light. Since the time of Daguerre, we have known that things photograph black, and I think the reaction of the average audience is that darker objects are and should be darker on the screen. There is a built-up formula in the motion picture audiences' minds that I have found in talking to the fans.

MR. JONES: I cannot agree with Mr. Waller's point of view. I realize we have been accustomed in photographic work to the distorted rendition of brightness which is given by photographic materials of the ordinary blue-sensitive type. There is little doubt that this distortion is in the opposite direction to that required by the great mass of our every-day experiences. I must agree that we are accustomed at present to the photographic convention of rendering reds and yellows as black. I do not believe, however, that there is any reason for continuing this practice which is obviously contrary to the logical requirements. The fact that we have for a long time been doing something obviously wrong is not an excuse for continuing. Perhaps Mr. Waller is correct in his opinion that we should change our photographic conventionalities somewhat gradually but I do not feel that our eventual aim should be to produce a rendering as constant as possible with the great mass of our visual experiences. The fact that we have counteracted a bad habit is no particular reason why we should not reform.

MR. ROSS: We have in mind a studio setting wherein a scene includes green trees, blue flowers, red cows, etc. Would it not be possible, for a given light source to determine the shades of gray paint which could supplant these colors whereby when photographed without filters their registration on an ordinary negative, without the use of one or more filters, would be the same as if the original colors had been photographed with panchromatic film and filters?

MR. JONES: I had the same brilliant idea a few years ago and thought it advisable to discuss it with someone who had experience

in studio work. I mentioned it to Mr. Palmer and he stated that the idea had been tried sometime ago and was a complete failure. One of the reasons he mentioned being chiefly responsible for the failure was the fact that the players could not work satisfactorily in a set painted only in tones of gray. I believe they complained that the atmosphere of the set was cold and emotionless. Having been accustomed to being surrounded in every-day life with color, the absence of color in the motion picture set reacted very unfavorably on their ability to play their parts with realism. It seems to me that there is some very sound psychology in this reasoning and I am a little inclined to doubt the possibility of constructing motion picture sets entirely in tones of gray which will be satisfactory from all standpoints.

MR. STEWART: The previous speaker has exactly anticipated what I was going to say. Some ten years ago, knowing that there are seventy-one distinguishable shades between black and white, I suggested to a director at the Vitagraph that only grays should be used in a set, and the idea was carried out. We took the shot, and of all the miserable things you ever saw, it was that. I do not quite agree with what Mr. Jones said that the temperament of the actor is affected; for I must tell you, as an actor, that we are almost blind to the surroundings when the director is telling us what he wants. But it appears that where the light was full on the colors, the grays wanted were obtained, but anything out of the full force of the light, the grays blurred away and the sense of color was entirely absent.

MR. WALLER: I want to go back for a moment. Mr. Jones answered me on the photographic rendition. I did not mean that we should interpret red as black, but I meant that we had a point of argument as to whether we should take a red view and how we should vary it. Mr. Jones states it should be lighter. I think the transition to the point where it should be lighter should be very slow. I think at first it should be darker.

MR. JONES: I do not wish to be misunderstood in my position on this point. There are of course many reds and yellows which are actually darker, that is of lower brightness, than greens. In such cases orthochromatic rendering is quite satisfactory. It is only in the rather rare cases where identity of brightness occurs between colors differing in hue that it is necessary to decide upon a distortion of orthochromatic reproduction. I cannot help but feel in these cases it is better to use a filter that will render these reds, yellows,

etc., as somewhat lighter than the color which they match in brightness. As a matter of fact I think the existence of this identity of brightness in the case of colors differing in hue occurs relatively infrequently.

MR. TOWNSEND: Would it not be a good idea to aim to use the filter required to render the flesh, eyes and hair of the actors in their proper tonal value, and let the red flowers, green leaves, etc., take their natural place? I understand this is the method which gives the best results in color photography.

MR. JONES: The procedure which Mr. Townsend suggests would be satisfactory in most cases but I can imagine instances where it would be an absolute failure. For instance, suppose the leading lady is wearing an especially beautiful example of the dress-makers' art. It is quite possible that the beauty of this material depends upon a design brought out by a hue difference between colors of practically identical visual brightness. Photographed with perfect orthochromatic rendering the design would entirely disappear. I grant this is an extreme case but it certainly might occur. I personally believe that correct orthochromatic rendering in ninety-nine per cent of the cases is the best that can be done. The critics of orthochromatic rendering of course always pick the ninety-ninth case and point out that it is wrong. In these few cases where a balance of photographic brightness exists in the presence of hue and saturation differences something must be done, but I do feel for the great majority of outdoor work that orthochromatic rendering usually gives best results.

MR. WALLER: If they were of identical brightness should we over-correct and bring out the red light or use a light filter and make the red darker? I don't say that I am convinced of my argument, but I think there is a point of discussion.

MR. JONES: I agree.

MR. STEWART: Whatever can be done by means of filters and panchromatic film that will enable blue-eyed actors to let us see they have eyes or blond hair must be an advance. We have Marguerite Marsh and others, who have ashen-gray or blue eyes, and on the screen they seem devoid of pupils. If we try to reproduce a play such as "Gentlemen prefer Blondes," how can we make the blondes look right with strong back lighting, as most of the electricians throw a shadow forward? Recently, we were photographing some girls, and I told the cameraman: "You have more light at the

back than in the front." He wouldn't believe it. I showed him with a pencil how the shadow came towards the camera. At the time I was making the photographs of paint-makers' charts, I also got a set of dyed hair, and had it photographed under the same conditions. I only got two colors, the white hair and all others black, because the blond color had a decidedly yellow tinge, which of course photographed black.

MR. JONES: That condition can be met by orthochromatic rendering; that is as far as we need to go. We made a little test to determine the rendition of blond hair. Miss Hope Hampton was in Rochester a short time ago, and the matter of rendition came up. We thought it very advantageous to find out if the hair would come out fairly light. A short reel was made on panchromatic film under tungsten illumination and it was very satisfactory without any filter. If you are working under daylight with such cases I think there would be satisfactory rendition with a K-2 filter, which is sufficient.

MR. WALLER: I don't want to talk too much, but a question came up about neutral grays being used in studios, and I have a little information on its recent use and success. It has been stated here that it was given up some years ago. I think many of you have seen the German picture, "Metropolis." I met Eric Pommer, when he came here for Famous-Players, and I asked him about the painting of the sets. All of them and the costumes were done in neutral tones of gray, and it is a beautiful piece of work.

MR. ROSS: I should like to ask if anyone knows if experiments have been made with fluorescent material in the hair or on the garments for the purpose of establishing tone color.

MR. STEWART: The only thing that has been used is aluminum and bronze powders; nothing fluorescent.

MR. COFFMAN: One application of the idea of photographing neutral grays to produce synthetic color values in the print is being regularly made. In the "Synthechrome" process for producing animated drawings in color the original drawings are made in black and white and shades of gray, and are so photographed as to give color separation in the negative. Any color process, either subtractive or additive, may be used for producing the prints. On the screen, characters which never lived move through surroundings endowed with color which never existed save in the mind of the artist. The same general method may be used for testing out color camera ideas without the necessity for building special cameras.

MR. ROSS: I should like to ask Mr. Stewart if the production which was a failure, if the grays had been photometrically determined before they were painted on the scene. When we speak of grays we have in mind there are three classes of gray; that is gray made from black and white, battleship gray, which is a mixture of black and white color, and slate gray, which is black and white and blue. It occurs to us that it might be possible to determine some particular shade of grey, which would, when photographed, represent color as seen in daylight.

MR. JONES: I should like to point out that my usage of the word "gray" refers to a color without hue. There is only one series of grays which extend from white to black. None of these show any hue. The colors referred to by Mr. Ross are not grays in the true sense of the word but are colors in which the saturation factor is low. The fact that they differ from each other in any respect other than reflecting power means that these colors must have hue and hence are not grays. I think in the interest of consistency we should confine our usage of the word "gray" to the hueless colors. Just so soon as a surface shows any selective absorption and requires the usage of such words as yellowish or bluish to describe it, it ceases to be a gray.

MR. STEWART: I preceded my remarks by saying that artists have conceded that there are seventy-one grades of gray between black and white. The grays that we used were based on the photographic reproductions of the color chart that I showed you yesterday. A paint maker's catalogue gave us all the colors which we photographed; we made no photometric tests of them.

(The following communications were received subsequent to the meeting at Norfolk, and in view of the lively interest displayed in the subject, are published.)

MR. ROSS: Mr. Jones, the fact that the use of correlative color shades of gray could be employed to substitute for other established colors has been previously conceived by yourself, and the fact that Mr. Pommer has stated that the successful picture entitled "METROPOLIS"—and produced by the UFA people—was photographed in shades of gray, would tend to further convince us that the correlative rendering of color on motion picture films and without the use of filters, or special films, is practicable. It certainly seems to be the ideal way as it permits the photographing of a set with ordinary film—as distinguished from panchromatic and without

the use of filters. This not only avoids the use of terrific light, which is costly, and the glare of which is injurious to the eyes of the actors, but also avoids the use of a more costly film.

When we speak of shades of gray, we refer to subdued white, the ultimate subduing of which results in black. White light, as is well known, is composed of all of the colors of the visible and perhaps some of the invisible spectrum and is only distinguished as such by the well known sensations on the retina of the eye. For the fulfillment of the plan we have proposed—namely, the substitution of correlative gray shades for the 71 established colors and shades mentioned by Mr. Stewart, the question of whether, or not, one of the established colors of the visible spectrum predominates is immaterial as far as the establishing of the shade of gray is concerned. In fact, we believe that to successfully produce the correlative shade of gray for some colors and shades thereof, it would be necessary to employ a preponderance of one or more established colors as distinguished from all other colors present other than black and white pigments. By correlative shades of gray, we always refer to paints, the composite pigments of which, when photographically impressed on an ordinary motion picture film, and without use of a filter, will produce a negative of substantially the same degree of high and low lights as would be produced by a film giving orthochromatic rendering.

And now referring again to Mr. Stewart's remarks, we wish to apologize for not more clearly stating our question. We appreciate there may be 71 colors and shades thereof for which correlative shades of gray may be substituted for photographic purposes. The obviously very important factor comprises the obtaining of the correct shade of gray as a substitution to produce orthochromatic rendering. We can conceive that to produce the required shade of gray for an original color or shade thereof it might require the photographing of ten or even one hundred shades of gray to satisfy say ten persons having normal sight, that the result was the same as if the original color or shade had been photographed with the correct filter and the use of an orthochromatic or panchromatic film, light sources being considered as equal. In other words, some 7,000 photographic tests might be required to obtain satisfactory correlative shades of gray for the 71 colors and shades of which Mr. Stewart speaks. Now, what we wish to determine is, were these 7,000 more or less

tests made, and if so, light sources being equal, how could the failures he mentions have obtained?

MR. V. A. STEWART: The name of the picture referred to by Mr. Pommer was "METROPOLIS" which was taken in Germany by the UFA people. It was news to me that the sets were painted in grays, though perhaps with the use of filters, which we did not have in those days, they might secure the effects obtained. In my experiments of some ten years ago, I was hoping we might have obtained some of the third dimension effects that are seen in many titles today, but the artist did not catch this spirit and only secured a flat, insipid result, not nearly as good as we were getting with my three quarter back lighting as used by Tom Terriss and his cameraman, Joe Schelderfer. This form of lighting is very general now. I must confess that I now cannot see any reasons why a color cannot be reproduced in its correlative shade of gray and get the same results as with colored backgrounds. You will remember that I had a paint manufacturer's color chart from which I evolved the colors for actors to use in their make-up.

Of course, in having this chart photographed I was careful to see that the plate used was coated with the same numbered emulsion as that used on the film. Although I furnished all departments with copies, yet we had occasion to use a number of trumpets with banners hanging thereto on which certain letters spelled out a name. The letters were gold and the banners deep purple. I told the cameraman they were of the same actinic value. He knew better and the inevitable result of a re-take followed. On another occasion, we were doing an episode in which the French thief, Arsene Lupin, wrote his name on the wall showing that he had stolen certain valuable paintings, and a yellowish chalk was used on a dark grey background for the walls. About two days were spent on this scene before it was discovered that the actinic value was identical and retakes were necessary. Though to the eye the name was outstanding, yet there it was lost on the photographic image.

When we are working indoors, I am inclined to think with you, that with people trained to know color values, there should be no difficulties in the use of monochromes, but when we are shooting out of doors, we have another condition and judging by the cameramen's feelings, they seem to want panchromatic, in spite of the extra precautions that must be taken in developing. When using this

film, the actors' make-up should be modified to suit the new actinic selectivity.

Referring to your concluding remark, there were no tests made as specified by you, for, as you probably know, there were internal disruptions at the Vitagraph at this time and I happened to be very close to Stuart Blackton and not all so with A. E. Smith and Blackton left the Company. At that time Blackton and I were going to light a set with Mazda lamps on my proposal and a lot of preparation was done towards this, but of course came to a sudden stoppage when he left.

MR. JONES: In answer to Mr. Ross I should like to point out first of all that panchromatic film is available at the same cost as ordinary film so that the use of sets painted in gray offers no advantage from this standpoint. Moreover the speed of this material is practically identical to that of ordinary film and filters which will produce very good approximation to orthochromatic rendering are available which have relatively low multiplying factors. This is especially true in case studio illumination is used which is relatively rich in long wave radiation, that is radiation within the region from 550 to 700 μ .

Theoretically it should be perfectly possible to determine the reflecting power of a gray to correspond to any specified color. This reflecting power of course will depend upon the spectral sensitivity of the photographic material and the spectral distribution of energy in the radiation from the source which is used to illuminate the set. Hence any change either in light source or sensitivity of the photographic material will necessitate the redetermination of the gray corresponding to a specified color. This might be a rather serious inconvenience as considered from the practical standpoint. There is one other factor which may be rather troublesome in arriving at a satisfactory solution of this problem. This is the intensification of saturation and the change of hue which occurs due to multiple reflections of light from colored surfaces. For instance let us consider a piece of buff colored fabric which as seen from the camera does not lie in a single plane but is draped in folds. This occurs in practically all cases of materials used for hangings, draperies, dresses, etc. In the folds of such materials the light is reflected back and forth from the fabric surface and the color as seen by the eye may be a relatively deep orange as contrasted to a light buff where the surface is viewed directly. Now this change in hue and saturation will mean

that the color index of that particular area is entirely different than at the point where this multiple reflection does not occur. It would be impossible, therefore, to state that this particular fabric has any definite correlative gray value.

As I said before it is perfectly possible theoretically to replace any color whatsoever with the corresponding gray, but when we consider the many complications it may be quite prohibitive from the practical standpoint. The establishment of the correlative gray for any particular color I think can be done by a method somewhat more simple and direct than the method suggested by Mr. Ross. Measurements of visual brightness made by the flicker photometer are perfectly reliable and quite independent of the normalcy of the color vision in the observer. To match this it is only necessary to make up a gray paint of the same reflecting power. Of course when I say gray I mean a color which is both visually and photographically non-selective.

I am inclined to believe that the failure to produce a satisfactory result by the use of multiple grays as cited by Mr. Stewart is due to one or more of the rather obscure factors, among which may be mentioned the change of hue and saturation due to multiple reflections, the change in composition of the light as conditioned by reflection from and penetration into the shadows, and possible also to the Purkinje effect.

THE CONSERVATION PROGRAM OF THE MOTION PICTURE PRODUCERS AND DISTRIBUTORS OF AMERICA, INC.

HICKMAN PRICE

THE subject I will present has to do with the conservation activities of the Motion Picture Producers and Distributors of America. I don't know how much of an opportunity you gentlemen have had to acquaint yourselves with the ways and means Will H. Hays has taken to conserve the resources of this industry, with which you are so directly allied.

The conservation work of the Motion Picture Producers and Distributors falls naturally under these headings:

1. New buildings—the replacing of old structures with modern, fireproof buildings;

2. Field service—these activities have to do with what are known as motion picture exchanges in the United States and Canada;

3. Relationship with those national bodies that have to do with conservation and the making of laws and ordinances that protect both the public and the industry;

4. That field of inquiry and service in which you are somewhat concerned—the mechanical aspects of devices having to do with safety.

Your identity with this industry may date back to the time when fires in film-distributing centers were more or less frequent. You may have in your files old photographs of buildings which were wrecked by fire, of districts in film distributing centers which were laid low by flames. If so you will all the more be interested in the new building program of the Hays organization. It has resulted in the erection during the last four years of two hundred and fifty new film exchange quarters.

In what respects does a motion picture exchange building differ primarily from other buildings? The answer is this: Because the product handled in these buildings, where it is examined and repaired, stored, and from which it is shipped, is highly inflammable, it is necessary that these buildings possess a minimum of fire hazards.

Greatest safety is had by limiting the space in which flames can travel, if once they start. The modern exchange differs from the old type of exchange in that fire resistive walls separate the different

departments. The vaults are separated from an outer passage-way. This is separated from the room for receiving and shipping. In turn this is separated from the room in which the film is inspected and repaired. This department is separated by a fire wall from the front part of the establishment in which sales and clerical work are transacted.

Motion picture exchange buildings are built today to put out fires before they start, also with the second idea that if fire does start that by reason of the separation by fire walls it will be controlled at its point of origin.

In these new buildings fire cannot sweep from one section to another. Vertical openings and horizontal openings are all protected.

A leading authority on fire prevention recently remarked that 90 per cent of spreading fires were due to unprotected vertical and horizontal openings. These buildings are at all points protected and covered.

Fourteen million dollars have been spent in the last four years in the construction of these buildings. The last word in building construction in this field is the Detroit exchange building, just completed at a cost of \$1,400,000.

There are two types of construction of exchange buildings. One is built several stories high. The Detroit building is of this character. The other type consists of single or two story exchanges built in rows. This type is found in Los Angeles, Albany and Memphis. Where realty values are not too high, single story buildings are best because exit to the street is more convenient. Buildings are in the course of construction in Seattle. They are being projected in New York City, Philadelphia, New Orleans and Cincinnati.

The Hays organization has promoted the industry's national building program by bringing together the realty owner, the financiers, architects and the distributors who lease space in these buildings. So much, briefly, as to the new building program.

Of the \$550,000,000 loss in property destroyed in the United States last year by fire virtually none of this loss was sustained in the business of film distribution. Partly because of this type of construction not one of the 15,000 persons who lost their lives because of fire in the United States last year were occupied in the film distributing business.

None of the 17,000 people who were injured because of fire in this country in this twelve months' period were engaged in this

business. There are more buildings to be put up, but this is a constructive building policy which is bearing fruit.

It is desirable that the organization doing this work know at all times what the field conditions are in the 644 film distributing branches in the United States and Canada. Once each month, through the Film Boards of Trade, branch managers composing a rotating committee accompanied by the Secretary of the Board make an inspection of every exchange in each one of these cities.

Once every 30 days, six hundred and forty-four reports are received in New York from these committees. These reports contain thirty-three questions. Every one of them has to be answered. The standing of each exchange is determined by the manner in which these thirty-three questions are answered. Once every 30 days in the Hays Office in New York there meets what is known as the National Rating Committee. It is composed of executives of the national distributing companies. It checks these six hundred and forty-four reports. It determines what is known as the National Honor Roll, which shows the rating of each of the branches.

An idea of the far reaching effect of these reports is had when it is appreciated that each time the inspection committees visit these six hundred and forty-four places, they conduct a fire drill. Every one of the several thousand employees participate. They have been instructed in their weekly fire drills held at irregular times, how to proceed when the fire gong is sounded.

At present approximately 125,000,000 feet of film are handled every day in these film distributing branches. This amounts in 300 working days to almost forty billion feet. In the term of 4 years it means roughly one hundred and fifty billion feet of film have been handled by several thousand persons who have received it, inspected it, repaired it, stored it, and got it ready again for shipment and made that shipment. In this 48 month period this enormous quantity of product has been handled with such safety including that part of it shipped over the railroads, that the total number of fires due to film in this period was only three, two each, with \$50.00 damage and one with \$300.00.

The progress thus far made as the result of this field service speaks for itself in every film distributing center. There is great improvement in the morale and spirit of employees.

Because there is a constant, regrettable change of managers and employees it is necessary that this resultful effort of maintaining good

housekeeping be continued indefinitely. In one eastern film distributing center there was a complete change of every branch manager in six months with one exception. All the general sales managers of national distributing companies have changed in the last eighteen months. This necessitates educating and training new groups all the while.

Safety education by word of mouth and the printed word proceeds continuously. A monthly publication and a series of monthly posters are issued.

Part of the educational program consists of showing a safety motion picture film.

Part of the success that has come in this work has been due to the understanding of this whole problem by state and municipal officials. They have aided in the adoption of a state model film law.

As engineers you are interested in conservation. Conservation of resources by reducing fire waste, as reflected in lower insurance rates, and increased efficiency in this work have been marked.

Times studies in exchanges caused the method of rotating film to be changed in these establishments with marked increased efficiency. A recent survey developed that 3 minutes were consumed in taking an ordinary show of eight reels out of containers and putting it into vault cans, and 3 minutes to go through the reverse operation, or 6 minutes for each shipment in and out of the exchange. This is being eliminated through the use for storage of the same metal cases in which film is shipped. Considering that 125,000 reels of film are handled every 24 hours, it is clear that in the aggregate an enormous saving in time is made in this way.

A number of technical, mechanical propositions are presented to us from time to time. The majority of these we refer to you engineers as the experts and authorities in your respective fields. A device is now under consideration which if it works in practice as well as in demonstration will go a long way towards reducing film fires in projection booths.

Through its conservation program the motion picture industry is becoming freer and freer of the fire hazards which formerly menaced it.

The success of this phase of the Hays organization activities is conclusive proof of what can be accomplished in an industry through carefully planned and executed trade association organization.

DISCUSSION

MR. RICHARDSON: There are one or two things I should like to call attention to. I do not know how far you go in these matters, but within the last few weeks I have had word from places where the insurance authorities are sending out inspectors and insisting the observation port in the projection room be 6 in. wide by 12 in. high, which is placing a handicap on projection, without any beneficial results. It is an outrage on the projectionist to compel him to work under such conditions, and a gravity operated fire shutter will close an opening 12 inches square just as quickly and effectually as it will one 6 in. wide by 12 in. high.

With regard to film inspection, the producer and the exhibitor must depend in considerable measure upon the projectionist for the excellence or otherwise of what the theater patrons view, and the projectionist cannot possibly place a perfect picture upon the screen if the film be in poor or bad physical condition.

I believe I am well within the facts when I say that I receive an average of three to four samples of film faults a day, or perhaps twenty five each week, which projectionists have cut out of films received from exchanges, accompanied by more or less vigorous complaints. Much film is still sent to theaters for projection which is in from poor to wretched physical condition.

There is still much complaint from both exchanges and projectionists that machine operators (I cannot call them projectionists) punch changeover signal holes or affix other markers near the end of reels of film. I would direct your attention, as I have repeatedly directed the attention of complaining exchanges, to the fact that this pernicious practice can be stopped merely by giving the films a thorough inspection each time and charging the theater for the footage thus ruined.

Instead of doing this, however, many exchanges affix a marker of their own, which is an outrage because it forces the projectionist to either omit several feet of each reel or else project to the screen the disfiguring marker, which latter real projectionists refuse to do. As the projection editor of a paper I receive a vast amount of complaints regarding film condition and could talk on the subject for an hour, perhaps interestingly too. Sending out film in other than perfect physical condition is hampering the showing of the finished product of the industry to the public, and oft times the "hampering" is pretty terrible too.

MR. PRICE: I appreciate this, and if I may, I will answer the last question first. I wonder if you happen to recall a paper read before this society about 18 months ago by John M. Joy, in which a survey conducted by the Motion Picture Producers and Distributors was presented. That report set forth conclusively the enormous loss that exists today because of film mutilation. Unquestionably, there are two sides to the story. The first is the side of the exhibitor who through negligence, carelessness, and inefficiency does not project shows with care. This is shown particularly when it comes to the change-over markings. Everything from tin foil to chewing gum is used with the result that many feet of film often have to be cut out when examined at the exchange. Steps have within the last fortnight been taken with regard to standardizing the system of change-over markings. The other side of the story is that of the distributor. In spite of the pains taken some film goes to exhibitors with faulty reels, reels not properly wound, and those not inspected with the diligence that they should be. I believe that steps will soon be taken whereby through the instigation of the Producers and Distributors, something with regard to the inspection of film and reels causing this loss will be brought about. In reply to your first question, I am not fully acquainted with the subject.

I am under the impression that the case is in New York state. I am glad to know about it and will look into it.

EFFECT LIGHTING IN THEATERS

J. H. KURLANDER*

General

MOTION picture programs today, especially as found in many of the de luxe houses, represent a combination of the earlier "straight movie" show with a trimming of vaudeville numbers formed against a musical background provided by an organ, orchestra, or stage band.

There are exceptions to this formula, of course, but animate performers, assisted by music provided by one or more means, are used to supplement the motion pictures which still constitute the principal body of the program.

With the fusion of these two, hitherto widely separated types of entertainment, it was only natural that the theatrical atmosphere which formed a part of the legitimate stage setting should also be used in constructing the modern form of entertainment peculiar to the presentation of motion pictures.

This rather indefinite, almost intangible, "something," usually referred to as "atmosphere," is provided for the large part, by means of effect lighting.

In its general aspects, so-called effect lighting is composed of three very broad divisions, as follow:

1. The projection of animated scenic effects;
2. The projection of color effects;
3. The projection of simple masks, cut-outs and special lantern slides.

The last two of the above named divisions are of comparatively recent origin, at least as regards the particular manner in which they are applied to the presentation of motion pictures.

Animated scenic effects, however, were used on the legitimate stage a score or more years ago and they have been retained, with practically no changes, until the present time.

* Brenkert Light Projection Company, Detroit, Michigan.

LIGHTING EFFECTS

Animated Scenic Effects

In general, scenic effects are imaged upon a suitable curtain, drop, or scrim by the simple expedient of placing a revolving transparent disc, on which the particular effect is painted, printed, or

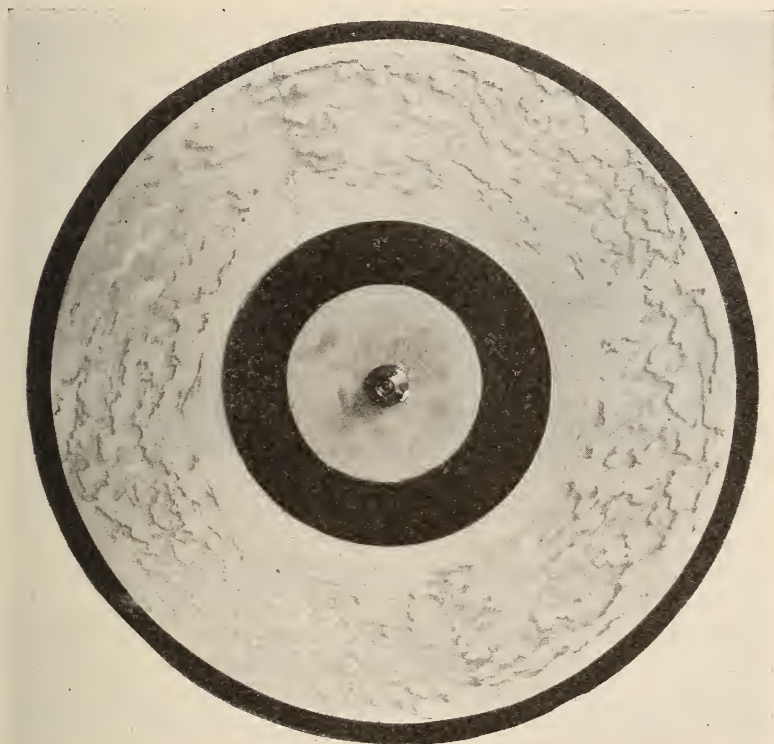


FIG. 1. A typical mica effect disc on which is printed, painted, or photographed, the effect scene.

photographed, before a projection lens, much in the same fashion that a slide is projected by a stereopticon lantern. Indeed, many of the commonly used effects are nothing more than special, elaborate, lantern slides so designed as to repeat themselves continuously upon the screen. The driving power for these effects may be obtained from either a double-spring clock-work motor or an electric motor, attached

to the metal casing which encloses the revolving disc for purposes of projection and attachment to the projector.

Mica is used in constructing the discs because it has the advantages of light weight; does not readily break; is suitably transparent; and above all, withstands a high degree of heat. An effect disc of the type just described is shown in Fig. 1. In the case of

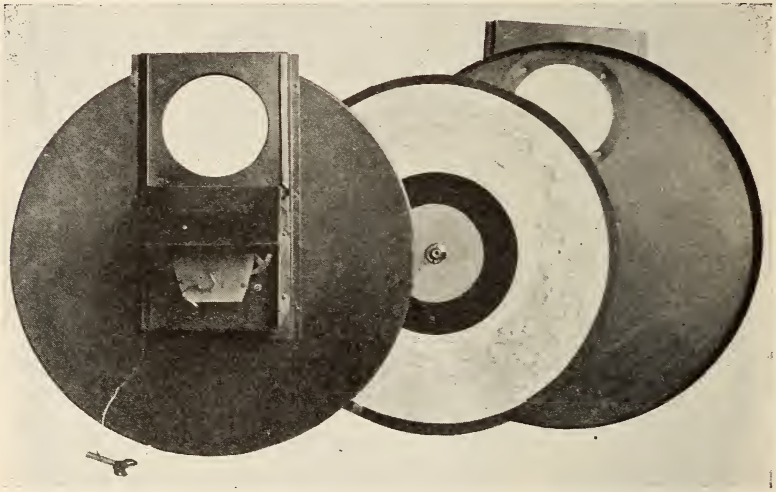


FIG. 2. Component parts of a disc type effect unit.

certain scenic effects, such as clouds and panoramic views of floods and cyclones, which are focussed in a fairly sharp manner upon the screen, the parts of the effect consist of simply the effect disc, the protective casing and the actuating, adjustable speed, clock-work motor.

Other effects, such as flames, ocean waves, babbling brook, etc., use the same parts in their construction with the addition of a 5 in. diameter glass ripple plate inserted just in front of the projected portion of the disc, so that the projection lens sees the disc through the rippled glass. The plate serves to give an irregular fused-motion effect to the local areas on the disc which would otherwise move across the screen in sharply defined rigid fashion. The component parts of an effect unit are shown in Fig. 2. Some effects, as, for instance, rain and snow, make use of either a special disc, or a special

plate placed before the disc in such a position that both elements are projected at the same time.

In the case of rain the standard 18 in. mica disc is used, the entire disc being opaque with the exception of the rain drops which are represented by elongated clear portions of mica for passing the light.

A rain plate, consisting of two separate plates of either glass or mica, on which have been printed closely spaced opaque lines, the plates then being placed together and rotated at a slight angle to form a zig-zag pattern, is then placed in front of the rain disc to break up the drops and give the effect of a shower.

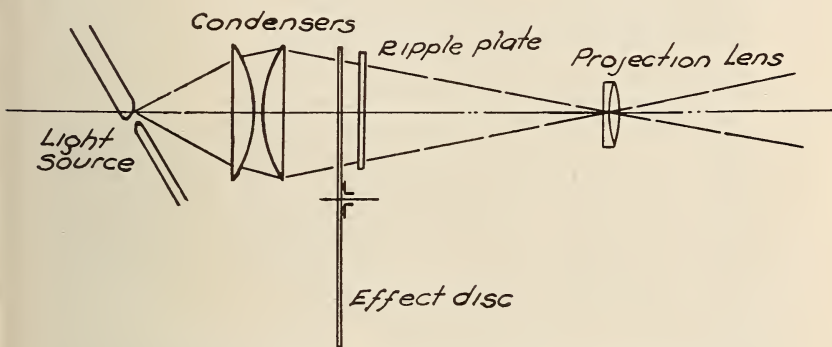


FIG. 3. Optic system used for projecting revolving disc effects.

A special disc is used in the case of snow, this being of a firm, opaque material in which have been punched many small holes (representing the snow flakes) closely spaced to simulate either a heavy or light snowfall, as desired.

Each effect disc is provided with a holding plate, the edges of which are turned over to form a lip so that the effect casing can be slid into a suitable holding plate on the projector in the same fashion that a colored gelatine is placed in position in front of a spotlight.

These holding plates on the effect casing are not rigidly fastened but can be swiveled completely around to permit of the effect casing being rotated when in position before the projector condenser lenses. In this manner the effect, as shown upon the screen, can be made to sweep across it in any desired direction.

The method of projecting upon the screen such standard effects as described above is briefly shown in Fig. 3 where it will be seen that the optic system used is that of the well known stereopticon form.

Some effects require two elements, one of which consists of a suitable lantern slide or a metal stencil-mask placed in the slide carrier of the projector. Of such a type is the waving flag effect wherein a lantern slide of a flag is projected to the screen through

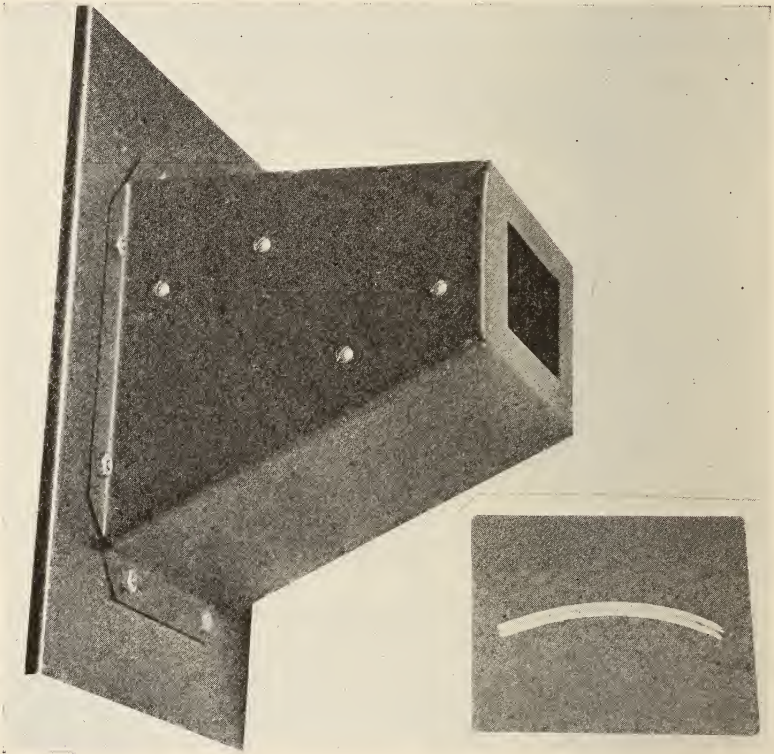


FIG. 4. Prism box and metal slide for producing natural colored rainbow effect.

the slots of a spoked wheel which revolves at a point between the projection lens and slide. The wave motion is imparted to the flag by the shadows of the wheel spokes sweeping across the projected image on the screen.

Other examples of two-element effects are the rainbow, aurora-borealis and lightning effects. The first named, see Fig. 4, uses a stencil of a rainbow cut in a metal mask which is then placed in the slide-carrier for imaging on the screen, and in front of the projection

lens, Fig. 5, is placed a prism box containing two optical prisms for imparting the necessary rainbow colors to the image on the screen.

Some effects are quite complicated as to structures, a good illustration being the moonlight water ripple (a two-element effect

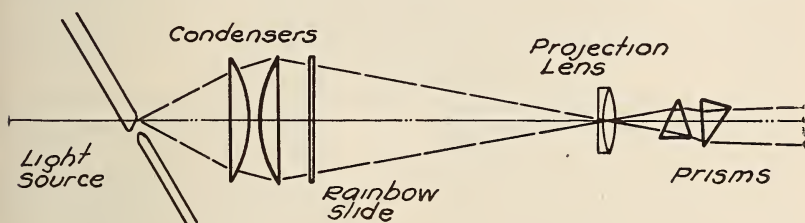


FIG. 5. Optic system for projecting rainbow effect.

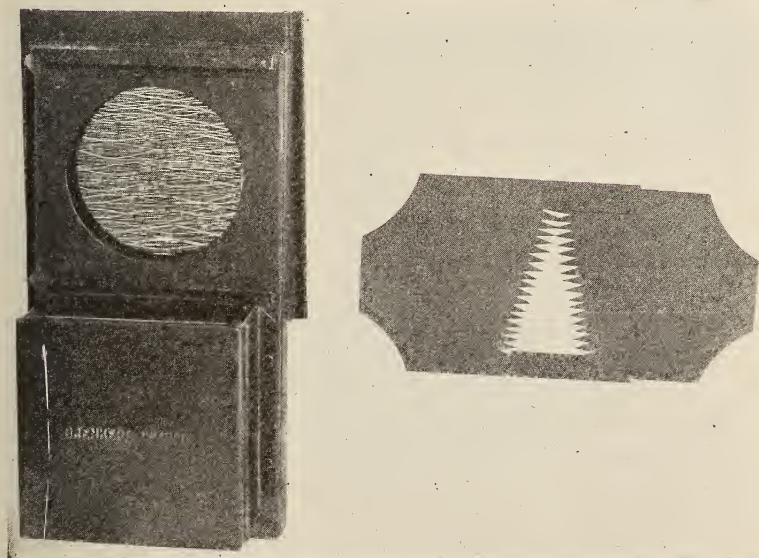


FIG. 6. Moonlight water ripple box effect and metal ripple mask.

using a ripple-box and a metal box) shown in Fig. 6. Three ripple plates are used in this device, each plate consisting of an opaque field across which fine water ripple lines weave so as to overlap and form a network.

These three plates are then caused to move up and down by means of a clock-work motor, being thrown out of step (120°) with

each other by means of three eccentric hubs on the motor shaft; each ripple plate being joined to its respective hub through a driving arm.

There are any number of animated scenic effects which can be devised, a few of those more commonly used being listed in Table 1, but in general all of them are operated in one of the ways described above.

Scenic lantern slides, in combination with an effect for imparting motion to certain areas contained in the picture, are also commonly used. Thus, in a slide of a camp-fire group, a flame effect can be used to show a realistic camp-fire with the flames leaping from the logs; or a mountain waterfall can be shown with the water tumbling over the brink of the fall to the bottom; or still further, the water in the pool at the base of the fall can be made to swirl about.

Indeed, by means of animated effects, volcanoes can be set into action; the fury of the elements invoked; and scenes can skip quickly from arctic to tropics, from summer to winter—while the patrons sit high and dry, in comfortable seats, with their galoshes and umbrellas safely parked in the vestibule at home.

Color Effects

Color effects, as projected from a special "spot booth" or from the projection room proper, are used in prologue work, special numbers, organ solos and even in the showing of motion pictures.

The principal control, in the case of simple colored lighting effects, consists in changing the colors themselves, or in changing the shape of the projected floods or spots.

Thus, a round, square, rectangular, or any odd-shaped colored spot or flood may be projected singly or in combination with one or more spots or floods of special shape to obtain a blending* or dissolving color action on the stage.

When the standard double-optic system type of effect projector is used, two different colored beams, of any desired shape, as, for instance, square, may be dissolved back and forth to obtain colors other than those represented by the gelatines used in the projectors. Or a square flood may be placed around the organ and the organist "head-spotted" with either a clear or colored round "spot." Combinations in this respect are quite numerous.

* "The use of color for the embellishment of the motion picture program," by L. M. Townsend and Loyd A. Jones, *Trans. S.M.P.E.*, Number 21, page 38.

A very pretty effect, and one which is often used in title and border work while motion pictures are being shown, is found in the

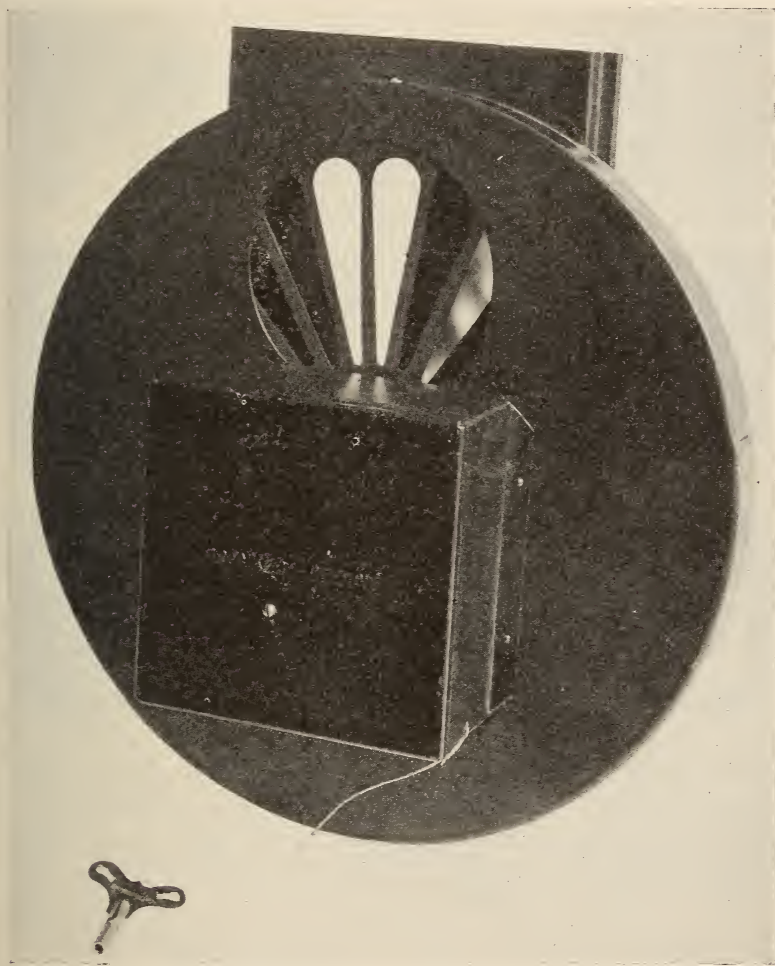


FIG. 7. Special color wheel and glass design plates for producing blending colors effect.

use of special glass design plates which are sharply imaged on the screen (or around the picture area) after which a special color wheel, consisting of narrow widths of various colored gelatines, is placed in front of the projection lens so that the colors, as they pass before

the lens, are caused to weave across the imaged design on the screen; a peculiar blending and fading in-and-out effect being obtained.

The effect apparatus required to accomplish this is shown in Fig. 7.

As used in connection with film title work, this color effect serves as a prelude to the principle title and is operated in the following manner. A blank leader, of a length consistent with the period of time it is desired to show the colored effect, is spliced between the last reel of one subject and the first reel of the next succeeding subject so as to make a complete 2000 ft. reel.

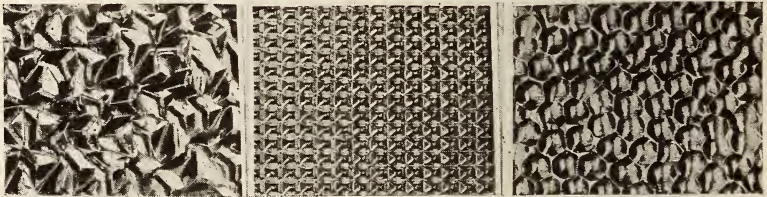


Fig. 7a. Effect Plates.

The projectionist, taking a cue from the end of the last reel as it passes through the projector, is stationed at the effect projector and when the cue is received he gradually opens a pair of vertical framing shutters which causes the blending color effect to be seen on the otherwise dark screen as if appearing from behind a pair of slowly opening draw curtains.

This effect is allowed to stand on the picture screen while the blank leader is being run through the projector and even after the title is projected onto the screen, the colored effect then serving as an animated field. Just before the picture comes on, the projectionist slowly closes the framing shutters, thus making the effect apparently disappear behind the closing curtains, leaving the motion pictures to follow closely on its heels.

By means of a special mask, provided for the purpose, the same effect can be projected around the border of the motion picture and left there until that particular subject is finished; or else a new design may be dissolved upon it to take its place, thus constantly changing the effect obtained.

Masks, Cut-outs, and Special Slides

By far, the greatest number of original effects are obtained by the use of simple masks, stencils and, in special instances, lantern

greatest field and many, indeed, have become quite proficient in this work.

Stencils of flowers, ships, hearts, vases, crosses, and many other objects are legitimate prey for such effects and are eagerly seized upon by projectionists in their quest for the novel and original.

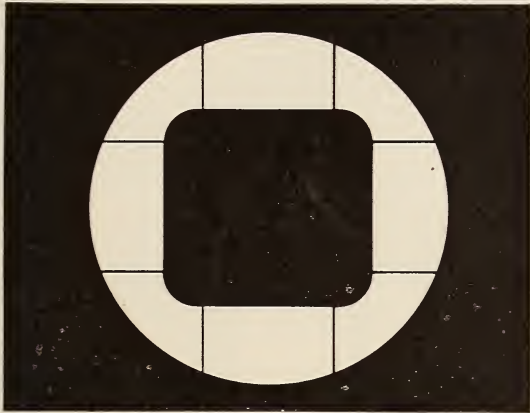


FIG. 8. Some typical masks, cut-outs and special lantern slides.

One man in St. Louis has made a stencil of every conceivable kind of flower, including a few that possibly never grew; another in Englewood, N. J., has a penchant for ships and on the slightest provocation will project a figure of a vessel of some kind upon the titles of all marine films.

Coming still closer to home, one of our own projectionist-members, will, without warning to anyone, sit down and make a pair of lantern slides consisting of a positive and a negative of some odd design and then dissolve them in colors back and forth upon the screen.

This work is unique and never becomes tiresome except for the physical exertion required, since an illustrative point in the current feature picture can be made to serve as the subject.

Some simple forms of stencils, a positive and a negative lantern slide, and a special mask, used in obtaining such effects, are shown in Fig. 8. Feature pictures, prologues, skits and special acts may serve as the inspiration for projecting novel and original effects.

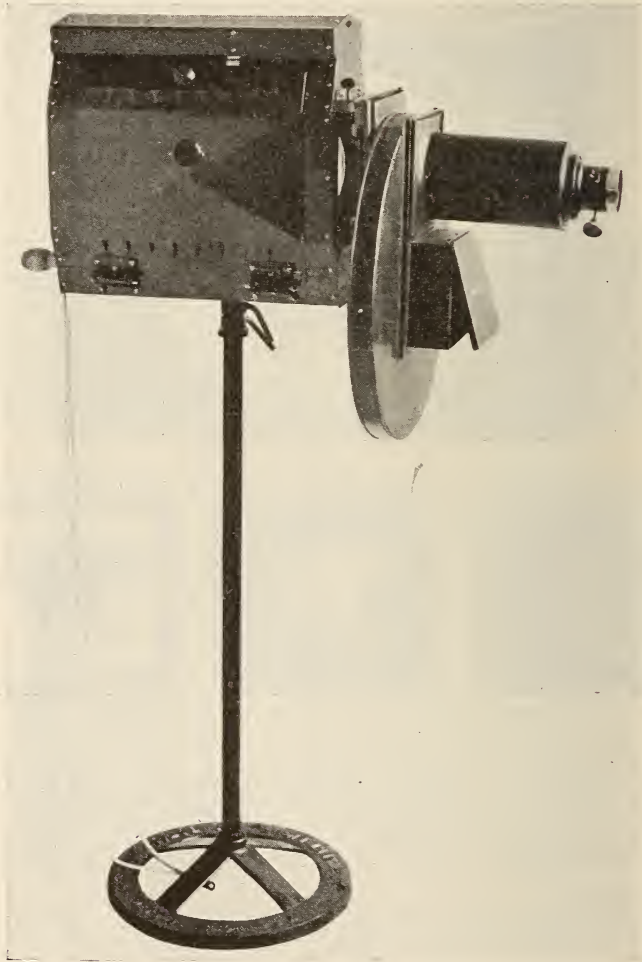


FIG. 9. Assembly view of spotlamp effect projector.

EFFECT PROJECTORS

The Spotlamp Effect Projector

In its simplest form an effect projector is nothing more than a spotlamp to which have been added an extra condensing lens for

converging the light to make it pass through an effect (attached to lens holder plate) and then on to a projection lens (attached, in turn, to the effect casing).

The complete assembly appears as in Fig. 9. A special effect holder for projecting two-element effects with such an outfit is shown in Fig. 10.

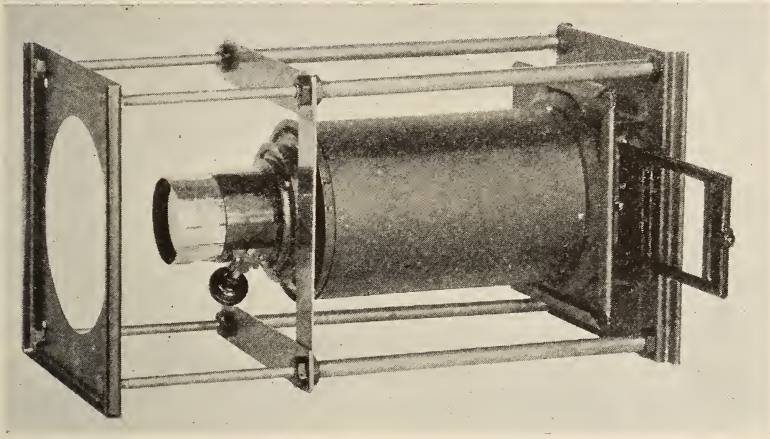


FIG. 10. A special effect holder for use with two-element effects as projected by the spotlight effect projector.

This simple device was designed primarily for use "back-stage" where it is particularly effective in that it can readily cover a large area on a short projection distance; can be easily moved about; occupies little space, and can be stripped of its accessories and impressed into spotlight duty when required.

Its adaptability to short focal length lenses for covering large areas at limited distances really acts as a powerful deterrent to its use in the projection room where, because of the greatly increased projection distance, long focal length lenses are required. There are no ordinary means for rigidly supporting such lenses on this unit and, indeed, even if there were, the device would be quite cumbersome and difficult to handle with ease and rapidity.

Furthermore, it can project only single effects so that the use of double effects would require two such units and two operators.

Modern practice in motion picture theaters only served to accentuate the inconveniences of such limitations and it was early realized that for this service a special unit, particularly designed to

meet the conditions in picture theaters was essential for proper effect projection.

It is true that efforts were made, and for that matter still are being made, to apply the spotlamp effect projector to projection room operation but a single demonstration, wherein rain drops appear of balloon proportions and snowflakes take on the appearance of a bombardment by snowballs, serves to convince the economical aspirant of the futility of his efforts.

The spotlamp type of effect projector, therefore, is definitely limited to back-stage service.

The Standard Double Effect Projector

The peculiar nature of the motion picture program—peculiar, that is, only in that it differs greatly from the heretofore accepted form of popular entertainment—revealed the need for a projection device especially adapted to producing those lighting effects which seem to find ever-increasing favor among theater patrons.

It was only natural therefore, that such a device, as illustrated in Fig. 11, should find a place in projection rooms. This is the now accepted standard double effect projector which first made its appearance some 4 or 5 years ago.

The advantages it holds over the spotlamp type of effect projector are as listed below:

1. Higher operating efficiency;
2. Produces effects which can be obtained by no other means;
3. Projects dissolving lantern slides;
4. Greater flexibility in operating;
5. Requires but one attendant for multiple effects;
6. Easy to operate.

Aside from these, there are certain advantages which result from its placement in the projection room since in this location it comes under the supervision of the projectionist who is, or at least should be, more skilled in handling such projection devices, than are other employees about the theater.

Furthermore, the centralization of such projection devices in the main projection room places the responsibility for their successful operation in one person's hands instead of distributing it among various persons about the theater. This naturally assists the systematic departmentization of the theater so necessary to efficient operation.

In its simplest form, the double effect projector is nothing more than a dissolving stereopticon to which have been added, see Fig. 11, horizontal and vertical framing shutters, iris shutters, dowsers shutters, a hinged slide carrier for swinging out of the way, effect

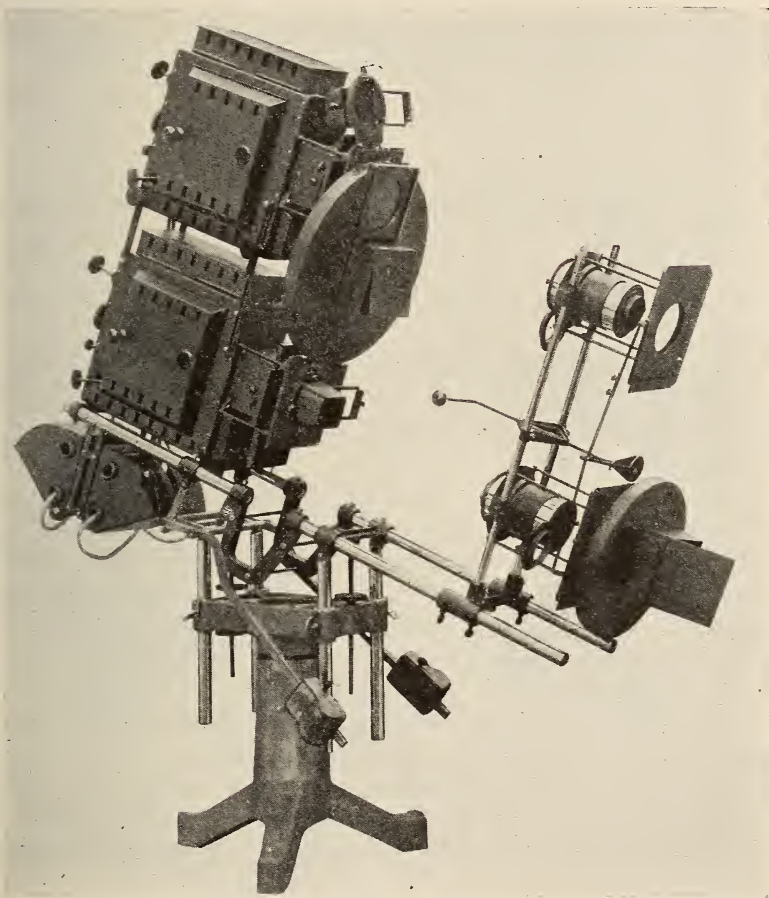


FIG. 11. The standard double effect projector.

holders, mask holders, extra projection lenses, a means for quickly altering vertically the direction of both light beams, and a means for quickly tilting or swiveling the entire projection mechanism so as to cover any desired portion of the "front of the house."

For projecting lantern slides, it is operated in the ordinary fashion like any other slide projector.

It can also be used in an emergency, although lacking in intensity, to project "spots" or floods of special odd shapes by the simple expedient of placing a suitable cut-out in the slide carrier, or by manipulating the iris shutter.

As an effect projector, it can produce either single or double effects by placing a revolving disc effect unit in one, or both, of the holders attached in front of the condenser lenses.

The upper system in Fig. 11 shows the method of supporting such effects in place.

Blending or dissolving colors, projected to any portion of the front of the house, are obtained by placing a suitable color wheel in the front effect holder, as illustrated by lower system in Fig. 11. Glass design slides, cut-outs, or ordinary lantern slides are placed in the standard slide carriers, located in the usual position, before the condenser lenses.

The framing shutters, iris shutters, and special mask holders, are attached, in complete assembly, to the front of the lamphouse in such a manner as to be between the condensing lenses and the standard slide-carrier.

Control over the area covered by the effects—whether projected on the motion picture screen or over the entire stage opening—is obtained by means of two projection lenses in each system. These lenses, one of which is of short focal length and the other of long focal length, are mounted at opposite ends of a lens barrel, see Fig. 11, and are pivoted to permit each being quickly swung out of the way so that a rapid selection of lens is possible.

The short focal length lens is for projecting effects over the entire stage opening, any desired reductions in size being obtained by means of the various shutters provided, or by using a special mask. The long focal length lens, nearest the screen, is more commonly referred to as the stereopticon lens since it is chosen with a view to projecting a picture of the same size as that formed by the motion picture projector.

The picture size can be varied, of course, by substituting lenses of any required focal length, which operation requires but several minutes.

This projector is equipped with either arc lamps or high wattage projection type incandescent lamps, whichever may be desired. The latter are satisfactory on projection distances up to about 100 ft.

Triple Effect Projectors

In the same manner that a spotlight is limited to the showing of single effects so, also, is the double effect projector limited to the simultaneous projection of two effects. There are occasions where

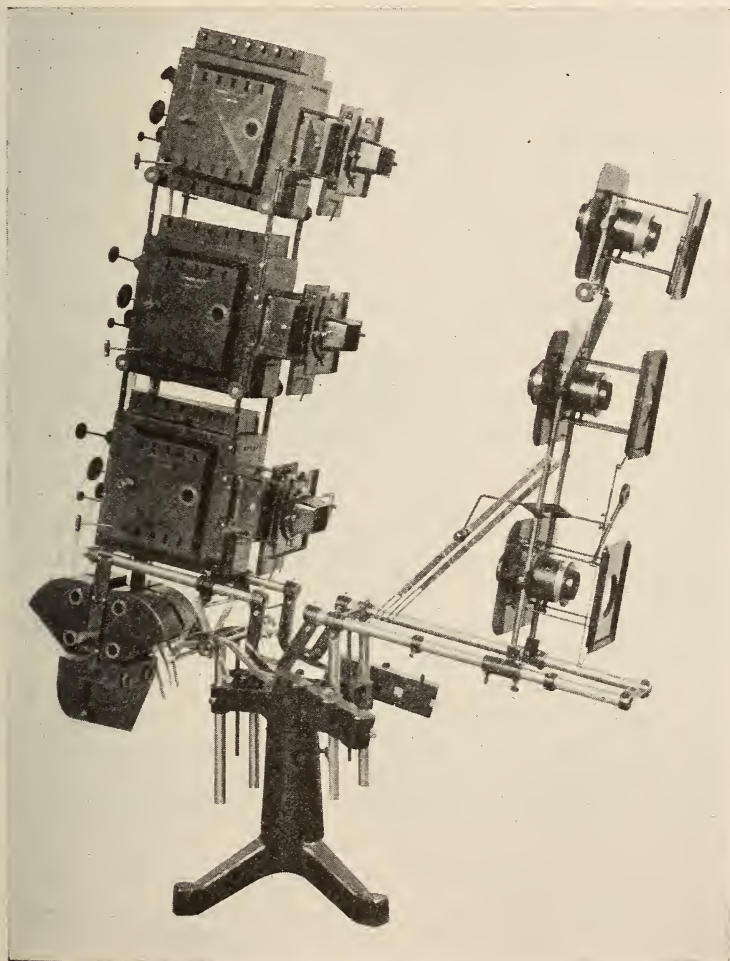


FIG. 12. A special triple effect projector.

the restrictions of the double machine are keenly felt, as, for instance, where it is desired to show dissolving slides along with a general animated effect.

Then, too, there are certain effects, such as a volcanic eruption where nothing but a triple-optic system device can be used. Such occasions, to be sure, are not as numerous as where double effects are desired; nevertheless there are times when the lack of these facilities is a drawback.

The triple projector is shown in Fig. 12. It is operated in the same fashion as the double type.

High Intensity Arc Single Effect Projector

The constantly increasing size of new motion picture theaters is making strenuous demands upon all types of projection equipment; not alone as regards spotlamps and effect projectors, but also upon motion picture projectors. A brighter source of light, the high intensity arc, has for some time past, been used for motion picture projection, but it was only recently that the same source was applied to the projection of lighting effects.

Being an entirely new piece of projection apparatus, the potentialities of this high intensity effect projector, Fig. 13, have not, as yet, been fully uncovered and its principal use, therefore, has been confined to producing colored floods, spots and odd-shaped illuminated designs.

In addition to being able to project single animated effects, color effects, and cut-outs, slides and the like, it appears to have unlimited possibilities in the way of special effects of a type heretofore impossible of attainment due to the limitation in intensity of illumination available for such purposes.

Its reception by theaters during the brief time in which it has been available has been, without exception, most favorable so that it seems quite likely that it will find a place in the projection rooms of all de luxe houses.

Briefly, by way of description, it consists of essentially the same elements as found on the standard double effect projector in that the necessary framing shutters, iris shutters, special mask holders, and adjustable slide-carriers are mounted, in one assembly, before the condensers of a standard high intensity lamphouse.

Three, or as many as may be desired, projection lenses of graded focal length are used, these lenses being locked in position when once focussed. Each lens is mounted on an adjustable, pivoted arm to permit of its being swung to one side when not in use. The adjustment consists of a thumbscrew for centering each lens in the optic system.

Should a "soft-focus" effect be desired, each lens can be easily and quickly slid on the base tubes to the proper focal position. Means are provided for placing an interchangeable assembly consisting of a light shield, dowser shutter, and effect holder, before each projection lens.

The entire working mechanism of the projector is carefully counter-balanced and can be easily swung from side to side, or tilted

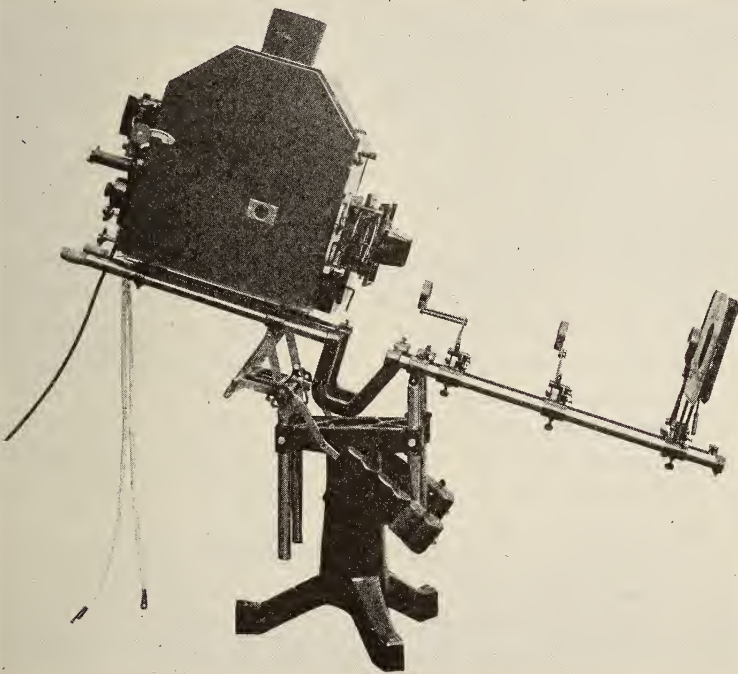


FIG. 13. The high intensity arc single effect projector.

up and down. Effects or gelatines can be placed in holders, either in front of the condenser lens or in front of the respective projection lenses.

It is true, some difficulty is experienced in preventing the colored gelatine, when so placed, from burning up too rapidly, although this problem has been solved, after a fashion. Heat resisting colored glasses seem to offer the best solution to this problem.

Conclusion

There is one other method of obtaining animated effects on which little has been said so far; that is, by means of motion picture films projected in the ordinary manner, or by rear-end projection through a translucent screen as is done in the Roxy theater.

This would, after all, seem to be the most logical method and strangely enough, it has been but little used. Natural scenes, otherwise unobtainable, could then be used as the background for prologues and similar work instead of building up effect scenes by use of two or more animated effects.

The principal objection which, undoubtedly, has acted so far to limit this method to strictly special cases, is that it is a more costly means of obtaining something, which in the main, can easily be produced from the front of the house. Then, too, a certain minimum projection distance back stage is required so that most existing theaters would have great trouble in applying the method.

Lastly, strange though it may sound, effects projected by means of strip film, "movie" fashion, do not appear to be as realistic as those obtained in the usual manner. It would appear, therefore, that this method of projection is suited only to the showing of complete natural scenes, unattainable by any other means.

It is quite probable that the "movie" method will find more extensive application, especially in the new theaters although it is quite unlikely that it will seriously encroach upon the now commonly accepted method.

Whatever the outcome, this much seems certain; that effect lighting in motion picture theaters is here to stay and will be even more generally applied in the future, since, to use a rather crude analogy, it represents the "sauce" which makes the "movie" more palatable to the average fan.

TABLE I

Some Commonly Used Animated Effects

- Aurora Borealis, changing color effect.
- Babbling brook.
- Blizzard effect.
- Burning forest, panorama.
- Clouds passing moon, moon stationary.
- Moving fleecy clouds with rising moon.

- Country scene, panorama.
- Cyclone effect.
- Cyclone with flying objects.
- Descending clouds for imaginary ascension trip.
- Falling flowers.
- Flying angels.
- Flying birds.
- Flying butterflies.
- Fog effect.
- Flood with floating objects.
- Falling flags.
- Fire and smoke effect.
- Flames.
- Inferno spectacular effect.
- Lightning effect, three brass slides, used in slide carrier, with lightning shutter used in effect holder.
- Moon picture slides, with appearing and disappearing clouds.
- Moonlight water ripple, with metal mask.
- Fast moving dark storm clouds.
- Slow moving fleecy clouds.
- Moving and evening sunset clouds.
- Moving river.
- Midnight sun.
- Ocean waves.
- Rain effect.
- Rainbow prism effect with metal mask.
- Sand storm effect.
- Volcano effect, used on triple dissolving projector or three spot-lamps. Eruption, flowing lava, rain of fire and ashes.
- Water falls effect.
- Automatic revolving color wheel.
- Blending colors effect, with glass design slides.
- Waving American flag effect.
- Flying bluebirds.
- Flying fairies.
- Falling sunbeams.

THE MOTION PICTURE IN SCIENCE

BY J. W. COFFMAN*

MOTION photography had its inception in an effort to solve a scientific controversy—for Muybridge made his epoch-marking trotting-horse pictures in an effort to determine the nature of the horse's leg-movements. It is also true that the pictures were made in order to settle a bet—but discussion of that phase of the subject must be left to some devotee of Lady Luck who may in the future present before this body a learned dissertation upon "Motion Pictures as first-aid to the Gambler; or African Golf—in seven parts."

The research scientist was rather slow to utilize the possibilities of this new instrument invented for his use—primarily because the motion picture is inherently spectacular, and the true votary of science has a great distaste for sensationalism. The scientist's loss proved the showman's gain, and the crude and awkward scientific toy of thirty years ago has developed into the basis of one of the nation's greatest industries.

And so, having reached the point where one may retain the vestments of conservatism and yet make use of the motion picture, the research man has taken up this instrument, the value of which he had previously largely neglected.

The growing industry itself had been making demands upon him, and leading him to familiarity with its technique. The very study of the problems of projection led to extension of physiological knowledge—the phenomena connected with persistence of vision and with color perception are much better understood today because of motion picture research. Indirectly, the films have accomplished much for photographic and colloid chemistry and for illumination engineering. Our own avowed profession of motion picture engineering, difficult though it may be of definition, is, of course, wholly the creature of the fitting shadows of the screen.

Used for research in fields of science not directly related to itself, the motion picture can accomplish much. In the observation of many types of phenomena, apparatus manipulation necessarily occupies a large part of the observer's attention. If the motion picture camera is substituted for the eye, it makes an accurate and impersonal record

* Carpenter-Goldman Laboratories, Inc., Long Island City, New York.

slides. It is here that the ingenuity of the projectionist finds its from which most of the factors of the human equation are eliminated. The action may be viewed and interpreted by an unlimited number of individuals at their own respective conveniences. And the fact that the same action can be viewed repeatedly leads to careful and unhurried observation with concentration impossible to any other method.

The wide range of control of the time factor permits observations otherwise impossible. The slowing down or speeding up of movements make their analysis possible, induce continuity of thought, and make clear the relationship of the various elements to each other. There is no great obstacle to the intelligible screen presentation within an equal space of time of the breaking of a soap-bubble, the growth of a plant from seed to maturity, and the movements of a glacier during a period of years.

This method of research can, of course, be profitably applied to our own problems of sprocket and perforation design.

The microscopist finds that the motion picture presents his world-in-miniature with a vividness unknown to ordinary visual observation. And the use of various light filters enables the camera to pick up details which would completely escape the eye. You have witnessed the remarkable results which may be secured by motion photomicrography at very slow camera speed. In what other way could the subject be as effectively studied as by motion photomicrographs of growing colonies of bacilli?

Typical of recent discoveries through cinematic research is Doctor Goodhart's (Columbia University) observation of a rhythmic muscular wave during certain movements in neuro-muscular diseases. Doctor Lloyd (McGill University) has discovered the mechanics of conjugation in the cells of the plant *spirogyra* largely through motion photomicrographic research. There will be shown you presently an X-ray motion picture of the stomach which led to important modifications in the theory of the peristaltic motions of the stomach.

This list may be extended indefinitely. The structural engineer uses the high-speed camera to determine the nature of stresses and strains in building materials—the physicist to determine the nature of electrical discharges—the ballistic engineer to study the flight of projectiles—the physical director to observe muscular co-ordination.

In the field of education the scientific motion picture has undeniable advantages. The day will come when every theorist and inves-

tigator will find it practically necessary to present a visualization of his theories and discoveries. He will be much the gainer, for visualization demands a degree of explicitness not expected of verbal presentation. A theory may seem perfectly plausible when expressed in words, but picturization is the acid test for plausibility. If you now believe that you have mastered perfectly some abstract idea, try expressing it in visual terms. The chances are that you will find much that still needs clarification in your concept.

Pictures make a direct approach to the understanding, while words are mere symbols which must be translated in terms of past experience. Many details of a picture may be caught in a single glance, while words convey visual impressions only through a laborious process of "building up."

And so the films fill the need for conveying to the student the great body of scientific knowledge which he must have as the background for original work. Through the re-creative power of the motion picture he may stand in outer space and watch the planets move, or go back fifty million years to the days of the dinosaurs. He may watch the teeming life of a droplet of pond water, or the first faint beat of an embryonic heart. Electrons, atoms, molecules, magnetic lines of force and other somewhat abstract entities assume a tangible reality when translated into animated drawings. Complicated machines may be shown in cross-section, yet still in operation, and an entire subject may be visualized in less time than ordinarily required to set up the apparatus for a single experiment.

The motion picture is our only means of transcending our physical limitations and breaking down the barriers of Space and Time—the films are the only ticket necessary to sit among the atoms in the theater of the monads, or among the stars in the theater of the Universe!

SOMETHING MORE ABOUT PROGRESS IN SUBTRACTIVE PROCESS COLOR CINEMATOGRAPHY

By F. E. Ives

THE brief paper which I now submit is supplementary to the one which I presented at the last Washington meeting of the Society, and is essentially a report of progress. In the former paper I stressed the fact that I started out with the idea of producing color motion picture films of satisfactory quality on ordinary positive motion picture film, and by the simplest and most direct means possible, and that I have consistently adhered to this scheme. I have continued experiments with a view to further simplification and speed of operation.

One simplification relates to the production of the negatives, which have been produced in a double camera with light-splitting device utilizing a dichroic reflector to economize light. This involves the use of a projection printer or other special differential registering printer for making the prints. Automatic registration is desirable, and is now provided for by making the negatives in a Bell-Howell pin registering camera on two special films run face to face between a glass plate and a pressure device. Using a special transparent green sensitive film in front, the definition of the back film negative, about which I felt a little dubious at the start, is astonishingly good, and I have heard no criticism on the score of definition. Of course this would not be possible without one excessively fine grained and transparent green sensitive film, and correct color selection depends upon a special surface dye screening on one of the films. The elimination of complicated double image cameras with light-splitting devices is an important achievement, though less important than the simplification and perfection of the color print making process, which chiefly determines the commercial value of the process.

The production of the color prints is now carried out automatically with processing machinery. The print from the red-record negative is developed and blue-toned and the base of the blue-print reconverted to silver bromide in one machine. It is well-known that the blue-toning process nearly destroys the light sensitiveness of the adjacent silver bromide, and that long washing has been considered necessary to substantially restore this sensitiveness. This slows up the process. In the course of experiments with the

Fox process in which the second image was produced in an uneven residual layer of silver bromide after dissolving out the base of the blue-toned print with hypo to prevent its redevelopment along with the second image, I made the discovery that a suitable adjustment of the hypo treatment had the effect of immediately restoring the light sensitiveness of the residual silver bromide, so that washing was necessary only to stop the solvent action of the hypo and remove most of it from the film. This led me to seek an agent which would accomplish this result without having a solvent action on the silver bromide, all of which should be retained in the film to insure even second prints. I was successful in this undertaking, but I do not wish to discuss the theory of the process at this time.

The first black image is now blue-toned and its base reconverted to silver bromide in a single solution, the sensitiveness restored in another single solution, and the film dried without any washing whatever. The second print, from the green-record negative is then made, with automatic registration, developed, fixed, washed, passed through a chromic acid-ferricyanide bleach, two dye baths and one water bath, dried, and the picture is finished.

Many people, knowing what perfect results have been obtained with a trichromatic subtractive process in still color photography, have suggested that color cinematography should also be made trichromatic. The combination of a blue-toned image and a red-to-yellow dichroic image produces such pictorially satisfactory results as to minimize the importance of adding a third image, but I have provided for this without unnecessary complication by coupling on a second simple camera and light-splitting reflector to make a blue-record negative, and making the yellow impression from this negative, (U. S. Patents 1,186,000, 1,188,939). I doubt if the added complication and cost would be justified for the general run of work.

MOTION PHOTOMICROGRAPHY WITH THE CINE KODAK

CLIFTON TUTTLE*

THE use of the motion picture camera with the microscope is by no means a new thing. The work of Comandon, Chevraton, Rosenberger, and others is well enough known so that the advantages of this combination need only brief mention. In educational work the motion picture offers an unapproachable method of presenting microscopic subjects before an audience—a method which is much more successful than microscopic projection or demonstration by means of the double lens oculars. In research, the motion picture camera can often take the place of a trained observer saving him many tedious hours over the microscope. In some cases a motion picture record offers an improvement over visual study by either slowing down or accelerating the action of a microscopic subject. It is possible by regulation of taking speed to analyze the mechanism of changes which can only be surmised by the visual method of study.

Bacteriologists, colloid chemists, and other users of the microscope would have benefited by more extensive use of the motion picture camera in the past had it not been for the considerable expense of 35 millimeter equipment and the inconvenience which the amateur encounters in the processing of 35 millimeter film. The advent of 16 millimeter film and the equipment for its use has practically removed these difficulties and it only remains to point out means whereby the 16 millimeter camera and the microscope may be brought together.

The camera requirements for photomicrographic work may briefly be listed as follows: 1. The lens should be removable. 2. The mechanism should preferably be of the hand driven type in order that there may be great flexibility in the control of speed. 3. The film plane should be close to the camera front, preferably within 3 or 4 inches, so that the camera may be brought close to the microscope. 4. The mechanism must run smoothly and the camera box must be rigid in its construction.

The model A, F 1.9, Ciné Kodak was used in the work to be described. It is much more adaptable than the model B. In fact only one change in the stock camera had to be made. The objective must be unscrewed from its mount as the optical system of the

* Research Laboratory, Eastman Kodak Company.

microscope is to take its place in projecting the image upon the film. Certain auxiliary equipment is desirable for motion photomicrography:—first, a viewing device which will permit of accurate focusing and adjustment of the image within the small picture frame of 16 mm. film; second, an automatic exposure device which will take pictures at any desired interval.

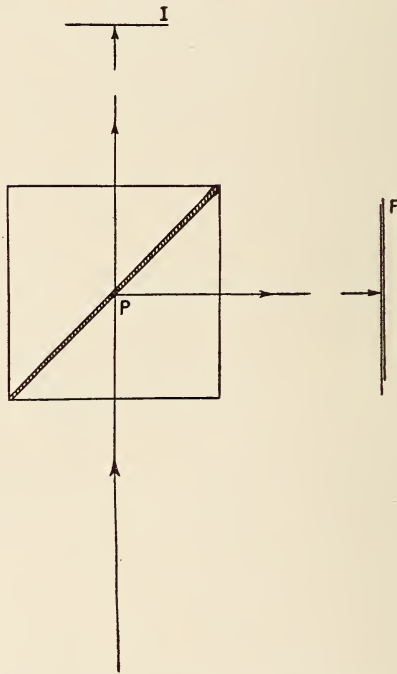


FIG. 1. Beam Splitter consisting of two right-angle prisms.

The design of a viewing device presents some rather interesting problems in mechanics, optics, and photography. It is not satisfactory to inspect the image as formed on the film. The light whether reflected or transmitted is not of high enough intensity for accurate focusing and the intermittency of the shutter is an annoyance. There should be a field for visual inspection which will be coincident with the film frame as to focus, shape, and size. Some form of beam-splitter then is almost essential, and the most practical is a cube made of totally reflecting prisms whose interfaces have been thinly silvered by cathode sputtering and subsequently cemented together. (See Fig. 1.) Such an arrangement transmits a portion of the light,

reflects a portion, and absorbs only a small fraction. After reflection, if the image is brought to a focus at the film plane F there will be another similar image at the plane I . FP and IP must be equal optical distances. The focusing and positioning of the film image F may be accomplished by inspection of the image I .

From the point of view of mechanical construction, it is much simpler to have the two distances fixed. As the magnification of the object slide varies with the distance of the image from the end of the microscope, some consideration must be given this point before deciding upon a value for this distance. Because of the very small size of the 16 mm. frame, it is certainly desirable to keep the magnification at a minimum in order to include as much of the slide area as possible.

For photomicrographers who are accustomed to working with plates up to $8'' \times 10''$ in size, the small image area of the Ciné Kodak frame must exert a cramping effect upon their generous ideas of magnification. Magnifications of 5,000 diameters or more which are common in still photomicrography will be impractical if one wishes to include much object slide area. The criterion of minimum magnification will of course be the result obtained in the final screen image. The ideal result will be a picture in which all of the detail which is resolved by the microscope objective will be distinguishable on the screen.

There are in this connection several points to consider: 1. The resolving power of the various objectives to be used; 2. The resolving power of the photographic emulsion; 3. The resolving power of the eye; 4. The magnification obtainable upon projection of the film.

Under advantageous conditions of vision, it is possible for the eye to distinguish clearly detail which is made up of lines and spaces or dots which are separated by $1/5$ of a millimeter. This will be true when the object is about 1 foot from the eye. If the eye is 10 feet from the screen, the finest detail of the picture will have to be separated by a distance of 2 millimeters or more to be visible. Suppose that we are projecting a 16 mm. picture 40 inches wide, we will then be magnifying the film about 100 diameters, and we should be able to see on the screen the image of detail which is separated by only $1/50$ th of a millimeter on the film.

As a matter of fact we are hardly safe in assuming that such fine detail is actually recorded by the film. The photographic image is made up of a heterogeneous mass of silver particles and the size

and distribution of these particles play an important role in determining the fineness of detail which the emulsion can distinguish. The reversed image of 16 mm. film has a resolving power of about 50 lines per millimeter when it is properly exposed and processed. It is much better, however, not to assume the full value of resolving power but to allow a small factor of safety taking 40 lines per millimeter as practical.

The conclusion is that the magnification by the optical system of the microscope and viewing device should be sufficient to separate the finest detail resolved by the objective by at least 1/40th of a millimeter on the film. Knowing the resolving power of all the objectives to be used for a given wave-length of light, and knowing the primary magnification given by each of these objectives at a tube length of 160 mm., one can easily compute the required secondary magnification which must be supplied by the added length of the viewing device tube. The results for a typical set of objectives can be seen in table 1.

*Showing the magnification required to separate the
resolved detail by 1/40th millimeter.*

<i>Objective</i>		<i>Magnification</i>		<i>Resolving</i>	<i>Total</i>	<i>Secondary</i>
<i>Focal</i>	<i>N.A.</i>	<i>Tube Length</i>	<i>Power</i>	<i>Power</i>	<i>Required</i>	<i>Magnification</i>
<i>Length</i>	<i>N.A.</i>	<i>160 mm.</i>	$\lambda = 500 \text{ m}\mu$	<i>Magnification</i>	<i>Required</i>	<i>Required</i>
1.9 mm.	1.25	97	5000 lines/mm.	125	1.3	
3.0 "	.85	60	3400	85	1.4	
4.0 "	.65	43	2600	60	1.4	
8.0 "	.5	21	2000	50	2.5	
16.0 "	.25	10	1000	25	2.5	
32.0 "	.10	4	400	10	2.5	

For the list of achromatic objectives a secondary magnification of 2.5X supplied by the optical system connecting the microscope with the camera will be sufficient. Similar computation shows that it would be sufficient also for most of the apochromatic objectives. Practically, a magnification of somewhat less than 2X has been found satisfactory since all of the resolving power of the lower power objectives is seldom required.

A viewing device which fulfills the foregoing requirements is illustrated in Fig. 2. It is used without an ocular because the quality of the projected image when using any of the standard ocular lenses is not good at the required image distance. The secondary magnification results from the increased distance between microscope and

image plane. The barrel slips into the ocular end of the standard microscope. The prism beam-splitter *A* transmits about 10 per cent of the image light and reflects about 85 per cent in the horizontal direction. The visual frame *F* is the same size as the film frame

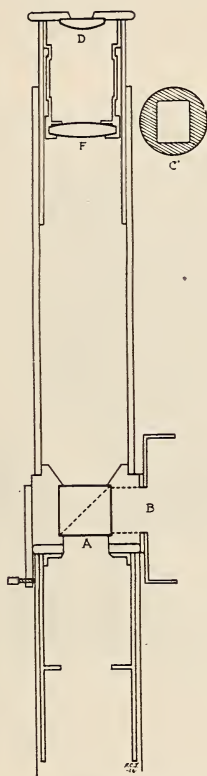


FIG. 2. Diagram of microscope adapter for Ciné Kodak.

and both frames are equidistant from the center of the cube when the finder is connected to the camera. The image in the frame *F* is inspected by an eye lens *D* which magnifies it about 8X. Since an equivalent effective magnification of the film can be obtained upon projection, the detail which is visible in the finder is a fairly reliable criterion of the detail which will be distinguishable in the finished picture.

The manner in which the view finder is used with the microscope is illustrated in Fig. 3. Means is provided whereby all rigid connection

between the camera and microscope may be broken before pictures are made so as to avoid the transmission of vibration from the camera to the microscope.

The view finder has proved entirely satisfactory in all cases of photomicrography which have so far been encountered. A negative achromatic lens replacing the ocular would no doubt have improved the optical performance of the objectives at this increased tube

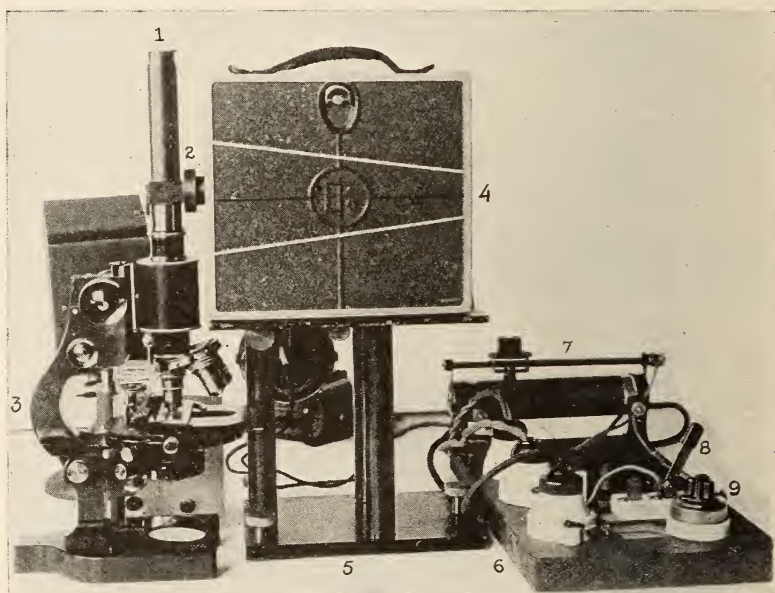


FIG. 3. Ciné Kodak with microscope and adapter in place.

length by maintaining the sine condition, but actually very little disturbance of definition has been noted.

In order to utilize all of the advantages offered by motion photomicrography in the study of microscopic changes, a device by means of which the exposure interval may be regulated is essential. Practically, the range from two or three times normal taking speed to a low rate of one picture every 3 minutes seems to be useful. For normal and super-normal taking speeds it is practical to crank the camera by hand using either the regular crank or a super-speed attachment which is supplied as one of the accessories to the model A Ciné Kodak. For the sub-normal taking speeds a continuous drive mechanism comprising a train of worm gears

operated by an electric motor has proved satisfactory. Such a device is very simple in construction and almost infallible in its operation. For reliability, the continuous drive has many advantages over any form of intermittent mechanism which the author has tried. There are no relays or clock controlled sliding contacts to give trouble. With the device illustrated in Fig. 4, it is possible to get a range of

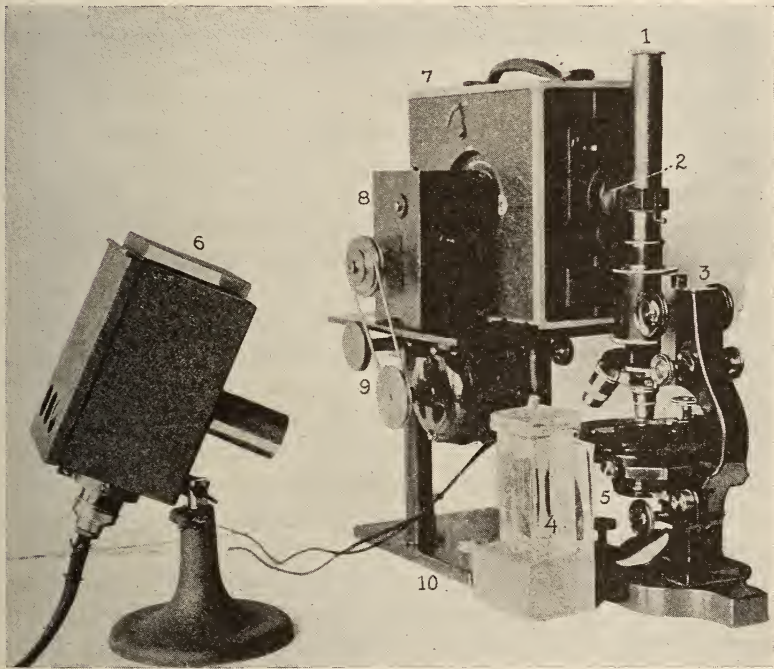


FIG. 4. Continuous Drive unit for Ciné Kodak.

speeds from one picture in 3 minutes to ten or twelve per minute.

As the Ciné Kodak is provided with a 180° non-variable shutter, the actual exposure time for a single picture is one-half of the interval. At first thought, it would seem that a prolonged exposure of over a minute might result in a lack of sharpness due to movement. Actually, this is not the case for if the movement is slow enough to require a slow taking speed there will not be sufficient movement during the required time of exposure to cause any apparent lack of sharpness. When pictures are made at slow speeds, the light intensity may be

reduced to a very low level. This is an advantage when working with organisms which might be injured by the intensity of light required for short exposure times.

The optical equipment of the microscope need not be of the very best to insure good results. Apochromatic objectives and an aplanatic condenser may give slightly better results than the achromat and a simple Abbé condenser but for most purposes the cheaper equipment serves as well. Bulky and expensive optical bench equipment is not at all necessary. If the building in which the apparatus is to be used is fairly free from vibration caused by traffic or heavy machinery, an ordinary table or bench will serve as a support. For high camera speeds it is desirable to set the microscope on a separate table. Apparatus* similar to that which has been described may be used in almost any laboratory. A small dark room for the development of test strips is desirable but the finishing of the film is done by the various laboratories of the Eastman Kodak Company.

It is hardly proper to belittle the difficulties of motion photomicrography. The worker will certainly encounter many troubles which he has never met in still photomicrography. Not the least of the trials of the cameraman will be the temperamental behavior of his subjects. The refusal of a protozoan actor to perform naturally under the eye of the camera will at times prove extremely exasperating. The problem of the cameraman is to make conditions as comfortable as possible for his actors. In making pictures at normal or supernormal speeds and high magnifications, the light-intensity required is very high. For opaque subjects or for dark field illumination, the intensity of a tungsten source may be insufficient, and one must resort to the crater of a carbon arc. Unless such a source is screened, the heat radiated to the slide will dry up all liquid preparations or kill the organisms. A dilute solution of copper sulfate—enough to tinge the liquid a faint green—in a water cell 1 or 2 inches thick will reduce the transmission of heat sufficiently for the making of short scenes. For slow taking speeds, it is possible to use a tungsten source, either the "Point-O-Lite" or the 108 watt, 6-8 volt ribbon filament lamp, and to reduce the intensity by the interposition of non-diffusing filters of gelatine between the lamp and

* The Bausch and Lomb Optical Company, Rochester, N. Y., are at present preparing to manufacture an improved form of the apparatus which will include a viewing device, camera stand, and motor-drive with speeds varying from 16/per sec. to one in 3 minutes.

microscope. If it is impossible to get the required intensity for the necessary taking rate, it is sometimes possible to slow down the action of a microscopic organism to a speed which will permit of sub-normal taking rates. The addition of minute amounts of chloroform or a solution of egg white will deter the movement of an organism.

The examples of photomicrography which are contained in the reel of film were chosen to illustrate the possibilities of the apparatus. In this reel are included some accelerated motion studies of the *penicillium*, a fungus, and the *megatherium* bacillus. The *amoeba* was taken at about one-third normal taking speed and the *Rotifers* were made at about twice normal speed. The author wishes to express his thanks to Dr. S. Bayne-Jones of the Rochester Medical School for his cooperation in the making of several of these pictures. Some of the special methods of technique which he has used will be described in a forthcoming issue of the Journal of Bacteriology in a paper by himself and the author.

It seems desirable to add as a supplement to the foregoing description a few remarks concerning the use of the standard motion picture camera with the microscope. In general the same arguments regarding the relation of magnification and resolving power apply whether one is using 35 mm. or 16 mm. film. The size of either frame is small in comparison to that of usual photomicrographic materials and for this reason it is incumbent upon the operator to keep the magnification as low as is consistent with visual and photographic resolution. In the case of most of motion picture negative materials, the resolving power is lower than that of the 16 mm. reversal film. It should be assumed that the standard 35 mm. film will not have a resolving power much in excess of 30 lines per millimeter. As a consequence the secondary magnification as given in the last column of table 1 should be greater than that computed for 16 mm. film.

When using short wave-length radiation as in the ultra-microscope the resolving power of the objectives is very considerably increased and it may be that under these circumstances a greater magnification may be desirable.

In the case of the standard motion picture, there is the possibility of using panchromatic film which is not at present available in the 16 mm. size. Panchromatic materials have proved invaluable in still photomicrography but it is questionable whether panchro-

matic film will be as great an advantage in motion pictures since most of the photomicrographic subjects are colorless unless stained. There are but few living organisms which can be stained without injury.

For a detailed discussion of the use of the standard motion picture equipment with the microscope the reader is referred to papers listed in the bibliography.

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DISCUSSION

MR. PALMER: My remarks are not in the nature of discussion, but I thought I might add something to the paper. We have recently been making photomicrographs with an ordinary motion picture camera. Of course, we did not use a very large magnification, but the job we had was to photograph a flea, and we built a special lens mount which removed the ordinary lens about a foot away from the film, and placed the flea within an inch or so of the lens. By such an arrangement we were able to get an image of the sitter on the film about half an inch in length. The flea was held by a very thin piece

of wire, so that he had to stay in front of the lens. We had to use very powerful illumination and our rate of mortality was very high.

MR. EGELER: I should like to ask Mr. Tuttle about the range of magnification used on the film.

MR. TUTTLE: The highest is about 200 times.

The Penetration of red rays.—S. Harcombe states that in determining the spectral distribution of a light-source when projected, and this obviously applies also with normal illumination, it has been found in the laboratory that three spectral distributions are obtained: one in which there is no atmospheric absorption and a second in which absorption has taken place over ranges of 2828 and 6760 feet. It is thus possible to determine the effect of atmospheric absorption on the color distribution in the beam, and also to obtain relative values of the transmission for the different wave-lengths. The extreme red and extreme blue ends of the visual spectrum are difficult to observe, but from 6700 to 4500A, the results obtained are reliable. Results so far obtained indicate that in all weather the blue light is absorbed more than the green and that there is a variation of absorption in the red—that is, in rainy weather the maximum transmission is about 6300A, while in damp weather the red transmission falls relative to the green. Generally speaking, the region with best transmission is from 5400 to 6600A (Proc. Opt. Conv. 1926, 1, 388). Cf. M. Luckiesh ("Color," 1915, 148). Paterson and Dudding (Proc. Phys. Soc. London, 1913, 24, 379) give the following table of the effect of absorption of colored lights:

Color	Effective range (miles)	Approx. trans- mission co-efficient of glass used
Red	3 -3.5	0.20
Yellow	1 -1.5	0.35
Green	2.5-3.0	0.17
Blue	0.5-0.75	0.03
Purple	0.5-0.75	0.03
Lunar-white	2 -2.5	0.15

Further data are given by Luckiesh, loc. cit.

THE EXAMINATION OF FILM BY PROJECTION ON A CONTINUOUS PROCESSING MACHINE

WM. V. D. KELLEY*

FILMS are now being processed by continuous moving systems in great quantities. The automatic developing, dyeing, toning and imbibition machines are examples. In most of these systems, it is desirable to visually examine the work, as it progresses, and while the

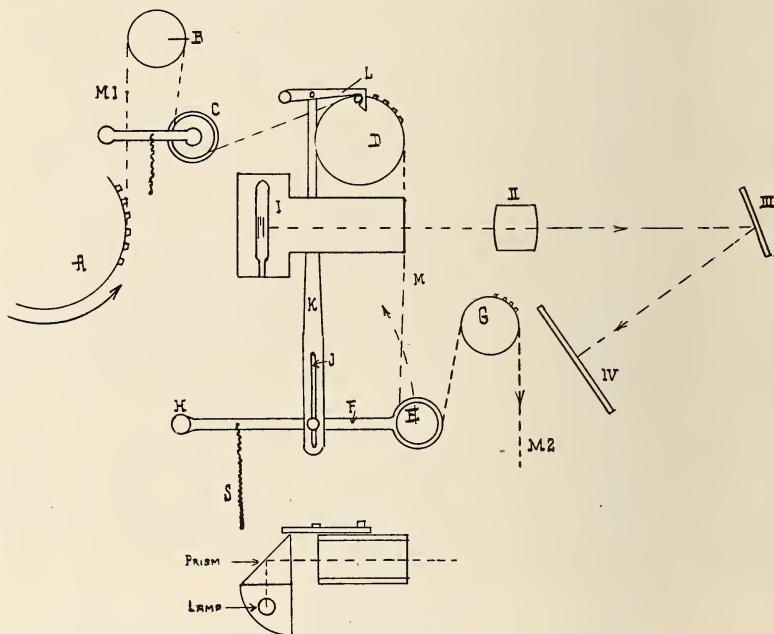


FIG. 1

film is wet. This is especially so where coloring or registration of two images is concerned, and the operator needs to know if he has made any errors in keeping the films in step. Also in a system for applying colors, where the amount of color applied is under the control and judgment of the operator, he needs to quickly know his results.

* Kelley Color Films, Inc., Hollywood, Calif.

It is customary for the operator to examine the moving wet film with a large magnifying glass. This is more or less satisfactory if the film is not traveling faster than 3 feet a minute—but when it travels at, say, 15 feet a minute, it is impossible to make any careful examination.

To improve upon the above condition, an intermittent device was designed which projects each fourth or eighth frame, and holds

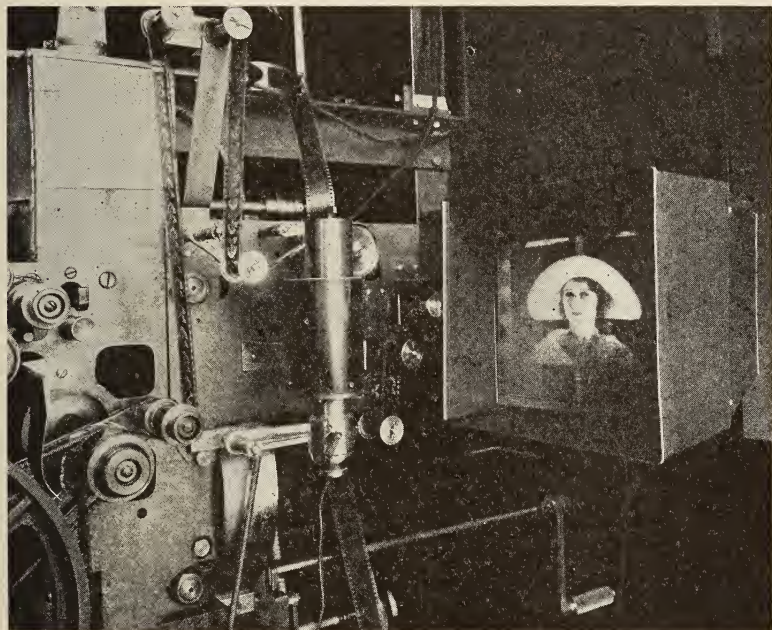


FIG. 2
A continuous processing projector

it still during the time that four or eight frames are passing through the balance of the processing.

Referring to Fig. 1 the film leaves the machine over a positively drawn sprocket *A*, then over an idler *B*, over a loose pulley *C*, which is mounted on a swinging arm and forms a loop of film of the desired length. Now it passes to the 8 picture sprocket *D*, to pulley *E*, on arm *F* over the driven sprocket *G*, and out of the machine. Arm *F* is pivoted at *H* and is drawn in one direction by coil springs. As the sprocket *G* is constantly driven and at the same speed as *A* and as *D* is locked by catch *J*, the loop of film *M* is taken up, drawing arm *F*

with it until the end of the slot *J* in arm *K* is reached and the catch *L* is lifted. Spring *S* then prevails, pulling the arm *F* which causes the film on sprocket *D* to spin around one turn or part of turn, depending on the number of stop pins on this sprocket. This also removes the loop at *C* which again takes up the stock from the machine *A*.

I is a lamp housing, back of which is a right angle prism to direct the light through the film *M* on a line with objective II. The picture is projected to mirror III and then to a ground glass IV. This glass is shielded and the pictures are viewed in daylight.

The film is so directed that the celluloid side is towards the light *I*, the film being held taut because of being on a slight curve from *D* to *E*. No gate or pressure of any sort is used because the film is wet. In this machine the surplus liquids are removed at a later stage of the travel of the film.

This device does not produce a motion picture. It does pick out each eighth picture, or if two pins are used on the eight picture sprocket, each fourth picture; holds it still and projects it to almost any size wanted for visual examination as to its quality.

The Universities of Naples and Turin, Italy, have founded professional chairs for the technique and chemistry of ciné films. (Filmtechnik, 1927, 3, 136.)

Hyper-sensitizing ciné film.—MM. Gibory, Bachelet & Berliet have used with marked success the following method of hyper-sensitizing film:

Pinachrome, 1:1000 alc. sol.	15 cem.
Pinacyanol, 1:1000 alc. sol.	8 cem.
Methyl alcohol	40 cem.
Distilled water	1000 cem.

The film was bathed, on silvered frames, for 3 minutes in the dark, then washed for 1 minute in running water, immersed in an 8 per cent solution of strong ammonia, again washed for 1 minute and dried on a drum. Development was effected with glycine after 2 minutes desensitizing with basic scarlet N. This method was found to more than double the speed of the film and it would keep 2 weeks. (La Cinémat. Franç.; Filmtechnik, 1927, 3, 148).

BETTER POPULAR PICTURES

BY JOHN GRIERSON

FOREWORD

In approaching the problem of better pictures, some people are so inclined to lose themselves in the possibilities of cinema as an art, that they forget the obligations of cinema as a public and popular institution. Others again are so abandoned to the doctrine that cinema is an "entertainment business," that they fail to insist on the development of the medium and the deepening of the appeal. It has seemed to me that I might be able to combine both positions. I begin my notes with an analysis of the limitations imposed on cinema production by the box office, and I proceed then to an indication of some of the greater things that might be done within these limitations. In this way I hope to avoid the usual comment offered by cinema executives: that critics forget the practical side of the business and ignore public wants.

The preliminary discussion of public attitudes is based on a perusal of the audience reaction data gathered at 485 Fifth Avenue and on the word of managers in a thousand and one theaters over the United States. For access to the data I am beholden to Mr. Henry L. Salsbury, of Famous Players-Lasky Corporation.

Part 1

WHERE any scheme of popular production is concerned, one must be prepared to start with the realization that the public is the final arbiter of form in matters cinematic. Theoretically and ideally, there may be no limits to cinema's powers—in imagery, fantasy, pure form, etc., etc.—but practically, the limits are set by the actual wants of the masses and the terms of their appreciation as these are shown in box office results: that is, in actual attention. The problem of cinema is the problem really of how profoundly cinema may develop within these terms; and criticism, if it is to have any practical bearing on the processes of production, may only consider the opportunities of producers, as it is willing to consider the practical obligations of producers.

If considered over a period of years, the popular demand at the box office may be seen to run along definite lines, and it can, to a certain extent, be articulated—however haphazard and untutored it may have at first appeared and however little it has had an opportunity to define its nature in the welter of cheap tricks and scurvy titillation of the senses which some movie producers have forced on it. I shall not say that infallible laws emerge, a knowledge of which will guarantee success at the box office; but an experience of past box office results and audience reactions, and a notion of how the show-

man's mind has developed within the last twenty years of cinema activity, force one to draw certain conclusions as to the spirit in which production must be undertaken.

These conclusions, as I shall submit, leave no room for pessimism. The world of popular appeal may seem at first sight a tawdry world to live in, but when the whole story is told, it may be discovered to be a place where opportunities are splendid and where a showman's life need not be undignified.

It is astonishing how far one or two of the greater producers have advanced toward a knowledge of the deeper principles of popular appeal. There has been of course no great altruism behind their efforts, and the end is as it always was, the greatest possible return in terms of cash; but on the one hand, their very worship of box office has tended toward a realism in their analysis of accounts, and the realism in turn has made them distinguish very clearly between the larger and the lesser reactions of the public. As a matter of fact, in the maze of circus effects, nothing has been more apparent than the incredible millions which were to be made if cinema could get under the skin of its people and touch them deeply; and the sleepless nights that producers have spent when some enormous success like "The Birth of a Nation" or "The Covered Wagon" has appeared in the ruck of average returns, represent the dim gropings of Barnum for the role of prophet. The term "entertainment-plus" is now commonly used among producers to indicate their vague realisation of a field of appeal in which cinema, to be really successful has also in some way or another to be profound. It records, for all who care to believe it, the fact that even among showmen—working as showmen will—the commercial appeal makes in the end for the recognition of the higher enthusiasms. The simple doctrine of the average showman (who calls it "service"), that it pays him to make his people "feel good," has its natural corollary that it pays him still better to make them "feel great." This, I believe, is the one great fact which illumines the present of cinema and gives promise for the future.

One producer—Mr. Lasky—has in public utterance given especial evidence of a critical understanding of these matters. Under Lasky's hands the investigation of the cinema public has reached curious dimensions. For years a complete account has been kept of box office records and audience reactions on each picture and every star. Till lately, the system of inquiry has been organized only

in the United States, but it will no doubt be gradually extended to include other countries as well. Exhibitors all over the country are required to send in an account of the effect of each picture: whether it "held up" or whether it "let down," whether it started that word of mouth advertising which is the magic wand of all cinema miracle, or plainly "flopped": what was said of the star, and whether from the new evidence, that entity is waxing or waning, what seems to be expected (indeed wanted or needed) of the star, what new faces have appealed. The exhibitors' own accounts are taken, and the public's reactions as they are gathered by posted questioners or eavesdroppers at the exits of a thousand and one theaters.

Taken over a period of years, on pictures and actors of all sorts, and read against the history of box office fluctuations and rising and falling reputations, these voluminous records take on a certain reasonableness, and become something like a great sociological document. As a guide to certain matters of comparative psychology the evidence is almost unique. Here one may take a single picture and follow its fluctuating fortunes among different types of audience and even among different nationalities. The same thing can be done with any actor with a specific appeal. Or one may take a type, say a western type of picture, and follow its fortunes as the mere horse-play of the woolly west passes into tales of the pioneers, and begins to add to itself the importance and the pride of history. Or one may take account of the relative box office values (other things being as equal as may be) of mystery drama, South Sea drama, Graustark drama, costume and historical drama, sheik and sex drama, or the authentic drama of actual scenes and living peoples; and decide roughly the relative success of the emphasis on youth or age, realism or romance, tragedy or happiness, the primitive and the simple or the sophisticated and the complex, on faith or fad, instinct or intellect, on fulfilment and drama with its roots in the practical or fantasy and escape with its roots only in play.

The secret of the whole matter—I shall develop the notion in a moment—is that encouragement, so far as cinema is concerned, pays better than education, better than art, better than mere entertainment, better in fact than anything;—and the "plus" in "entertainment-plus" conceals the very real demand on the part of the public that when it goes to cinema, the needs and desires, dreams and ambitions of its daily life, will be engaged and appropriately resolved. It seems that what people want more than anything of cinema is

practical example and a renewal of vitality: they are not at all the disinterested spectators of Kant's Aesthetic Judgment, except in the broader forms of comedy. All the major failures in cinema can be set down to the fact that however successful the pictures in question may have been in other directions, they have forgotten this fundamental principle.

Therein lies (I speak of all production intended for majority audiences) cinema's obligations—and also its opportunities. For it is clear that if such a relation holds, cinema merely abandons the role of art to take on a role even more important. Its creative possibilities as a guiding force among the needs, desires, and ambitions of emergent democracy, are obviously enormous.

To proceed to the detail of these matters, it is clearer than most things that the outcome of a picture must be positive rather than negative, that it must concern itself with youth and achievement rather than with age and disintegration, with matters that instill optimism rather than those that suggest a reason for pessimism. Tragedy has failed in cinema as realism has failed. The box offices of the cinema world shiver whenever youth and sunshine and enthusiasm and evident triumph fade from the screen. This is abundantly evident in the box office records of "The Last Laugh," "Greed," "Black Stairs," "The Salvation Hunters," "Caligari," and a dozen other films of outstanding power. Even where there is no great pessimism evident or any emphasis laid on failure, drabness of scene is enough to decide the fate of a picture. And even the atmosphere of the underworld can be exploited up to a point.

To this drabness European pictures have been peculiarly liable. Their preoccupation with the slums, their harping on poverty, their tendency to represent workmen and workgirls in the dismal atmosphere and setting of obvious, conscious, and complacent inferiority, their preoccupation with weakness and failure in general, do not serve them well in the larger cinema market. They are lacking in that spirit of bubbling vigor and unchastened self-confidence which it seems the fate peculiar of cinema to supply in this modern world and the peculiar achievement of American production (be it ever so bad) hardly ever to miss. An American once remarked to me that European pictures "don't make you feel any good." This principle I believe touches the root of cinema success and accounts for much of the failure of European cinema in the past. A recent English picture, "Hindle Wakes," though cinematically far above the average,

may be taken as an illustration. Though the central figure (a young and independent girl) might have caught up the enthusiasm for youth and independence in which cinema audiences are so rich, she fails largely to do this. The issue is slight and not likely to command vital attention, and her youth and independence do not bring her to any remarkable goal. She begins as a work girl, she ends without a future, and the atmosphere about her carries more than a hint of the uncertainty of that everlasting economic uncertainty and petty fear which makes English proletarian life so distasteful on the screen. The net result in the case of "Hindle Wakes" is that while as cinematically good as, say, "Declass  " or "Manhandled," it is not likely to have the effect of these pictures at the international box office.

In a recent analysis of the trend in production Mr. Lasky summed up his view in these words: "The mere entertainment or program picture is gone forever: it is not enough that a picture be well made: it is not enough that it tell an interesting story or that it be acted by a good cast. Every picture should have a basic theme or element which will lend itself to exploitation." Lasky was addressing the showmen of America and no doubt the word exploitation carried visions to many of their minds of tie-ups and trailers, stunts, drives, twenty-four sheets and ballyhoo. But Lasky's reference, I know, was quite different. Themes which will lend themselves to exploitation are those to which men will more eagerly respond; the issues, in a word, which prove more acceptable occasions for drama and readier basis for encouragement, because they mean the more to the masses of the modern world.

Production, indeed, is falsely keyed unless it takes continual account of average ambitions and average preoccupations. It may romance to its heart's content, and indeed it must romance, but the roots of its romance must be in the every day. Cinematic romance on a swift generalisation must be the romance of fulfilment rather than the romance of escape. Graustark dramas, costume dramas, historical and bearded dramas are only successful at all where there is a modern and democratic motif of Cinderella or third son achievement or a scheme of easily comprehensible heroics and romance to relieve them. The average cinema mind is not historically disposed: it is only practically disposed, and it is not easily moved by descriptions and issues of a life which it does not share. Abstract and foreign settings, faces, figures, fates, fantasies and fashions not easily identifiable with its own, are always of doubtful interest. This conclusion,

which may be read in the fate of "Faust," "Siegfried," and a dozen other films of removed romance, necessitates a very careful handling of all "foreign" material.

"Nanook" and "Moana" give further illustration of the general principle. Both were in a sense "foreign" films, the one a dramatic description of Eskimo life, the other a dramatic description of Samoan life, and both were made by the same talented director, Mr. Robert Flaherty of the Royal Geographical Society. From any cultivated point of view, both were great films and each had its individual quality of beauty, yet at the box office "Nanook" was an enormous success, "Moana," a failure. The reason is simple. "Nanook" is a film of action and struggle: it creates suspense, brings excitement and touches those satisfactions which western peoples can understand. The storm and stress of blizzard play through it, the threat of starvation and disaster and the bleak shadows of an hostile earth are constantly present: the need for effort and the value of courage are at the root of it. Indeed no matter how foreign the setting and how strange the characters, the issue is a primitive issue found in all barbarian states where the struggle for life is arduous and constant: the masses of the western world can share it easily.

"Moana," on the other hand, engages a more subtle issue. In Samoa where the film was made, life is bountiful and all the ways of men are leisured and pleasant. Men, women and children are born with flowers in their ears and carry them till they die; and so distant are effort and force from their ideology that even the vocal struggles of Caruso played on a tourist gramophone are considered grotesque and comical. The natural relation between the sexes, moreover, provides no source for what western people consider romantic excitement.

Indeed to provide that sense of drama for themselves without which it seems men cannot live, the Samoans have had to invent it, and this is the theme of Mr. Flaherty's picture. They found it in the ritual of tattoo, in the self-imposed pain by which each youth whose heart is "malosi" or strong achieves manhood and the honor of manhood. But this for the more practically preoccupied mind of the western world is something incomprehensible, and among average audiences the issue is not felt at all deeply. "Moana," for all the beauty that it held, lived a precarious and forced existence under the box office sub-title, "The Love Life of a South Sea Siren" and it has not earned the two hundred thousand dollars it cost. It

goes with three other Paramount films ("Peter Pan," "A Kiss for Cinderella" and "The Beggar on Horseback") into the list of good films which have not the heart of the matter in them.

The complete failure of fantasy in cinema can of course be set down to the same cause. Fantasy may be imaginative and in the last sense aesthetic material, but unless it is comic fantasy (a very successful genre as the Mack Sennett films will testify) it is poor stuff for the crowd. The Barrie pictures ("Peter Pan" and "A Kiss for Cinderella") were high above the average as pictures but they were not popular successes. "The Beggar on Horseback," a satirical fantasy and one of the finest pieces of work done in America was a complete failure: "The Thief of Bagdad" was rather less than a success. It is doubtful if "Caligari" means anything outside the ranks of the intelligentsia.

All attempts at psychological studies, it may be guessed, have shared a similar fate. Apart from the fact that the medium cannot portray the more subtle continuities of the mind with anything approaching ease, and is very liable to lose its visual energies if it attempts a syllogism, audiences it seems are too absorbed by the objective world and the manipulation of it to be interested in such matters. The visible cause must be in adequate and normally sensible proportion to the visible effect. Struggle within one's own mind, whether the struggle be against complexes or traditions, means little or nothing. The average mind is in that sense anything but self-conscious. Indeed any struggle with intangibles (even when the intangible is personified and called the devil) is a trifle suspect. In "The Last Laugh" the motion of an old man's heart breaking because he lost a uniform was incomprehensible and the film failed as a majority picture. In "The Salvation Hunters" the notion of a perfectly healthy youth being afflicted for seven reels with an unknown fear, was incomprehensible, and the film failed as a majority picture. The gradual disintegration of two people in "Greed" was largely incomprehensible and entirely distasteful, as a majority theme. "Caligari," "New Year's Eve," "The Secrets of the Soul," "The Sorrows of Satan," "The Student of Prague," are other films which illustrate the principle. A dramatic emphasis on the mental processes which determine events, especially when they determine abnormal events, does not appear to be of primary interest.

In short the attitudes of the cinema public in its principle manifestations is not an aesthetic one, but a practical one. It is

absorbed primarily with its own affairs and the issue of them. For this reason it is that the love interest is so important on the screen and why unless the appeal be especially exciting in other directions ("Nanook," "Grass," and "Beau Geste") the way of any film which dispenses with sex is hazardous. It is for this reason too that courage is the most admirable quality on the screen, and why evident struggle (to the bewilderment of all Orientals and not a few cloistered westerners) is as essential to the dramatic material as light is to the screening of it, and why objective achievement (visible, tangible, and in the last instance possessable) is almost a holy requisite.

At the lowest level these principal interests can be met by sheer sensationalism, and sensationalism was the first and most obvious one of popular sentiment, as it was of popular journalism. But here emerges what may be set down as the second principle of cinema showmanship. Pictures may be too sophisticated, too subtle, too foreign, and too far-removed from their public, but taken all in all, they can never be too big. Once regard is paid to the simples and fundamentals of the practical mind, production can be as imaginative as it pleases. Better results indeed have come when sex interest has been merged in romance and violence in adventure; and the results have been better still where the romance has slipped into the confines of poetry and the adventure has taken on the size of human significance.

American films have never done much in the first regard; and their interpretation of the love interest remains for the most part shallow in the extreme. The relation of its heroes to its heroines is as a rule conceived trivially and unimaginatively and the manifestation of feeling in the matter is generally obvious and uninspired: this despite the medium's immense capacity for visual imagery and significant atmosphere. The reasons doubtless can be found in the conditions of American life. On the other hand, under box office influence such incidental characters, of sex drama, as the vamp and the villain, have undergone a change in the direction of subtlety, and feminine appeal, if never exactly profound, has come to be portrayed in terms of greater naturalness. When, as in "Variety" and "The Merry Widow," some cinematic vitality has been breathed into the love motif, or where, as in one or two of the Fairbanks pictures, the love story has been set in especially pleasant places, the box office effect has been certain. In this matter, however, Americans taken all in all, have failed dismally. They seem unable to relieve themselves of a concentration on 'le contact de deux epidermes', or

at least unable to treat it imaginatively, and I believe that if production will carry the love stories of the screen into poetry and plausibility, the incomprehensible facility of the movie amour will straightway appear at the box office for what it is.

In the matter of adventure, American producers have shown a greater understanding and in this regard they have everything to teach the producers of other countries. The field of action first exploited by the cowboy pictures has been extended to include the exploits of the pioneers and the more picturesque and adventurous incidents of history with the consequent deepening of the dramatic appeal. The word "epic" has crept into the producer's vocabulary, only dimly understood as yet, but indicating a popular form in which the exploits of men add to their first primitive interest a direct feeling for the sources of national pride and human importance.

It would of course be easy to overemphasize the intelligence of American producers in this respect, and in a recent list of over two hundred releases of all kinds, I count eighty-two western pictures which make no effort to exploit the deeper strata of adventure. It is apparent moreover that any grasp of the principles involved would have extended the field of action still further, into the epic affairs of industry, the romance of commerce, the trafficking of men around the seven seas, the building of cities in the wilderness, and so on. At the same time the advance, such as it is, gives an important lead to what undoubtedly must prove a most fertile field for cinema material in the future.

I think of the advance as due almost entirely to the Famous Players organization. It made "The Covered Wagon," and realizing thereafter that in an art of movement it is as well for the movement to be momentous, it followed up with "North of 36," "The Thundering Herd," "The Vanishing American," "The Pony Express," "Old Ironsides," "Wings," and "The Rough Riders." Other production units have caught the principle and have made or are now making pictures dealing with the transcontinental railroad, the United States mail, the Panama Canal, the history of the automobile, and the exploits of the Hudson's Bay Company. Not all of these have been great pictures, but all of them have had the germ of cinema truth in them, and all have been box office successes of the first order.

Greater things still could have been done if the term "epic" had not been unnaturally and stupidly associated for so long with "western" pictures and if the true field of "epic" adventure had been realized.

More still could have been done if the personal elements in these sweeping films had been handled less trivially. The Americans have very correctly sold their history with a tale, and invested their scenery and action with the charm of a personal romance; but in most cases the personal elements have overbalanced the larger theme and detracted from its dignity. This is a continuing and seemingly ineradicable fault. So the action be deeply set and powerfully executed, the love interest need not be over-emphasized. "Beau Geste," "Potemkin," "Nanook" and the first part of "The Vanishing American" will serve to demonstrate how a film may even dispense with it entirely, but in any case, the difficulty could be overcome (and the women who make up the larger half of cinema audiences, satisfied) by a more subtle use of the medium in the presentation of it.

The best guide to the nature of cinema's public relations is of course the attitude to the central figures revealed in the star system. There has been a tendency to deplore the star system, and people accustomed to stage conditions are apt to think of star values as acting values pure and simple. This comment applies particularly to England, from which I write. Both attitudes miss the special significance of the cinema relation. It is perfectly true that some cinema figures have been foisted on the public by advertisement, and perfectly true that the method of selling pictures (before they are made) on the names of the participants, has encouraged a false importance in minor personalities; but at the same time, a value attaches to personality on the screen which has nothing to do with acting ability; and in the really significant cases, the relation of the star to the public is too intimate to be set down to the wiles of advertisement and the necessities of salesmanship.

Two factors combine in the making of cinema stars. In the first place the medium makes the portrayal of different characters much more difficult and far less attractive than it is on the stage, and lends itself rather to one-role actors, or people who are visually interesting in themselves,—in a word to personalities. This point I shall take up later. In the second place, majority audiences want personalities rather than clever actors. They want figures with a continuing life and a continuing role in the world from picture to picture, with whom they can identify themselves. The star system is psychologically very like a mythological system. It represents a collection of personalities who, in cinematic terms, suggest the manners and ways to be loved and possessed, or most to be despised and avoided. They

are in a word the figures who are especially significant of life as it is understood, and best fitted as guides to conduct. They are on the whole a little higher than the angels, and are rewarded accordingly. An analysis of the church's relations to the masses of the modern world (while greater education, widening horizons, and greater personal ambitions are putting a premium on inspiration and example) may indicate the position which cinema with all its faults is slowly capturing.

"The handling of stars," as this art has been developed in America, involves all those intricate processes which may be conceived to attend the manipulation of divinities. It involves continual care that the company in which the star is seen is fitting,—that the things that befall him are fitting (a false step even in fictional life is held against him),—that he never suggest his knowledge of ignoble things, play an unsympathetic part or in any way destroy the illusion of perfection which makes him an example. In his fictional world the star is manipulated very much as Machiavelli would have his Prince manipulated in the political world; and the principles set down "for the conduct of a Prince who would gain renown" are as much the source of a star's authority as his cinematic presence and his power of expression. The personalities which go furthest are, of course, those whose appeal is to the vivid primary interests I have named in dealing with themes. For the rest, the public is not unlike Fortune in the classical description: "It is better to be adventurous than cautious toward her, because Fortune is a woman; and it is seen that she allows herself to be mastered by the adventurous rather than by those who go more coldly. She is therefore womanlike, a lover of young men, because they are less cautious, more violent, and with more audacity command her."

The mistakes of Gloria Swanson in the latter part of her career, the ultimate failure of Meighan to hold his worshippers despite their deep-rooted loyalty in the past, and the waning of stars like Hart, Nazimova, Nita Naldi, and to a certain extent, Pola Negri, illustrate one or two of the thousand natural shocks that stars are heir to. In some cases failure has been due to decreasing cinematic vitality or the passing of an agreeable personal appearance, in other cases to disagreeable associations or the effect of roles which detracted from their dignity. An ambition to follow the example of stage actors and demonstrate versatility has been especially fatal. The cinematic career of Pola Negri illustrates the folly of attempting to play in

sympathetic roles a figure whose natural cinematic character does not lend itself to them. In this case excellent acting, heavy advertisement, and a choice of stories especially designed to capture the affections of the public have hardly succeeded in overcoming the decree of the camera.

This worship of stars will indicate how much the private fortunes of the individual are concerned in average cinema relations. It may be that the Russian people are different from others in this respect for "Potemkin" had no central figures. If there were stars in "Potemkin," it was a case of the cruiser co-starring with the mob in Odessa. "Potemkin" however was directly and, I believe, consciously inspired by the Communist way of thought, and interest in heroes was purposely eliminated in favor of an interest in collective life. The film meant the less for that reason at the average box office in America and its unprecedented command over speed and action, fight, fury, and terrible death, could not overcome the original difficulty, that the average spectator of more individualistic cultures cannot see himself written in its record.

"Potemkin," however, illustrates a possible departure from the tyranny of individualism. On Broadway where this film ran for a couple of months the film inspired more enthusiasm among its admirers than any film has ever done before. The spectator, however individualistic in his outlook, will dispense temporarily with an emphasis on personal fortunes the moment a picture touches the sources of his pride. A few appreciated "Potemkin" critically for its cinematic values but the general audiences which cheered their way through the film did so for the revolutionary cause it espoused and the pride of class to which it appealed.

I can think of no other similar case (the American producers have always been careful to personify their patriotic issues), but I can imagine a field of production where stars would scarcely be necessary for a certain limited box office success. The trouble with such films is that their success is likely to be confined to the audiences whose associations and loyalties they affirm. I do not mean to deny the possibility of producing patriotic films which will lend themselves to general exploitation, but their patriotism, I fear, will have to be incidental to more universal sources of pride. It will have to be realized creatively in achievements all can appreciate rather than stated in the more exclusive terms of flag-waving and parade.

Western civilization is so rich in dramatic material that there should be no great difficulty in accomplishing this. There are subjects aplenty in the progress of industry, the story of invention; the pioneering and developing of new lands and the exploration of lost ones, the widening horizons of commerce, the complexities of manufacture, and the range of communications: indeed in all the steam and smoke, dazzle and speed, of the world at hand, and all the strangeness and sweep of affairs more distant. If this material were treated imaginatively and energetically with all due regard to the nature of the medium and the nature of the institution, it would cut through to the very sources of Western pride and patriotism without overstepping the laws of international decency.

Part 2

In the first section I have dealt with the nature of cinema as a popular institution and I have noted that a deepening of appeal is possible in certain directions without any interference whatsoever with the demands of the public. There is the complimentary problem to consider. What are the possibilities of cinema as a medium and which of these possibilities lend themselves best to popular production?

The interesting point in this connection is that not only does the popular demand allow for a worthy use of the medium, but within certain limits it ensures the development of cinema according to its own inherent nature, according to its own most obvious powers. These powers consist briefly in a preoccupation with movement which enforces a drama of action, and an insistence on the visible which discourages psychological niceties and all syllogisms whatsoever; a flexibility which permits of inexhaustible variety in scene, setting, and dramatic emphases; a command over the natural which makes for authenticity (or "realness") and allows for the more objective forms of poetry in which all can participate. Cinema is a thoroughly objective and in the main a non-intellectual medium; it is in its essence a popular one.

These matters are more apparent on a consideration of the form of cinema development in Germany. The German product, except for one or two brilliant exceptions, has not begun to compete with the American in international popularity, and in the exceptional cases, production was partly imitative of the American model ("Variety" and "The Waltz Dream"). The German school has come

to cinema from the stage and has been inspired from the first by the desire to appeal to the intelligentsia. Its form is an indoor form; its material is shot through with the psychological preoccupations which are more easily handled under stage conditions. The Germans seem to have been chiefly interested in the new medium because of its wider range of theatrical effects: it has given them a solution of their former troubles with the immobility of the stage. Their development of the medium has been so able in this single direction and their effects have been so fantastic and powerful, that German cinema has been regarded by many as truer to the nature of cinema than any other school and the one school to be imitated. This is a fallacy and a very dangerous one, for while it has helped the skill of other producers to absorb the technical ingenuity of the Germans, it has been responsible for any amount of dullness and any amount of artificial theatricality, which has nothing to do with the screen.

The reason is that where cinema is preoccupied with affairs psychological (in other words with affairs essentially invisible and never adequately represented except in prose or in poetry) it has to load its visual effects of conduct and setting with undue emphases: and with its too meaningful looks and too deliberate movements, this medium of action is slowed up past average endurance. "Caligari," "New Year's Eve," "Back Stairs," "The Treasure" and a host of other German pictures provide ample illustration. The creaking of the dramatic machinery is of course much more obvious in the case of tragedy.

Theatrical terms are peculiarly foreign to cinema. Theatrical effects are undoubtedly possible and possible to a degree unheard of under stage conditions owing to the camera's capacity for miracles of one sort and another; but expressionism which is accepted in a theater, where the light of day and natural effects are out of the question, becomes, if made the general rule, strained and unnatural in cinema, where the light of day and the wonders of the light of day are so clearly to be drawn upon. Not only do the majority prefer to have their drama easily and unstrainedly rather than in fantasies and grotesqueries which involve a detachment from the obvious sources of drama, but it is clear that in avoiding the natural world which it has at its command, cinema is depriving itself unnecessarily of much that lends itself specially to cinematic treatment.

Mr. Douglas Fairbanks, in a conversation with Mr. Robert Nichols, stated the other or non-German point of view very elo-

quently: "Ours is a young, elastic and athletic medium," he said, "and youth, heroism and athletics suit it. We should keep it in the open air; cinema has gone indoors and consequently begun to wither."

There are good reasons for this opinion, without the natural preference of cinema audiences, and without the natural preference of Mr. Fairbanks in favor of his own production. The lifeblood of an art of movement is obviously movement itself, and while, by controlled tempi, arranged rhythms, powerful sets, and camera magic, great dramatic effects are possible in the theatrical tradition, the easier and richer and greater power of outdoor movement is missing. The thought of horses and waterfalls will serve to demonstrate this. The point is more obvious still if one takes account of the natural dramatic power of ships and the sea, of the flight of birds and the sweep of plains, of crowds in the streets and regiments on parade. The scale of movement is larger and greater variation is possible. And there goes with these the guarantee of more abundant visual life.

There is another matter. The acting manner, however significant and dramatic it be made by theatrical emphases, is never in cinema nearly so effective nor ever so patently powerful as spontaneous behavior. "Children and animals are the best screen actors: they are themselves and the camera is relentless," Fairbanks added to his first comment. In Hollywood this capacity for naturalness is recognized in definite terms. Actors, they say, "have the bubble," or they lack it; they are "photogenetic," or they are not. The terms of course mark nothing but a sense of the distinction; but this has become so strong that directors and producers have to find satisfaction in the notion that the camera is some mysterious instrument endowed with "second sight" which reveals and exaggerates the distinction between the natural and the false.

A partial explanation is that, faced by a world of silent forms and bringing people to a contemplation of them, cinema focuses the attention on the visual character of its figures in a way impossible in ordinary life and on the speaking stage. Where personality has to register itself within the limits of shape, mass, and muscular movement, the race is obviously to those who are distinctive and pleasing in these matters and who in the ordinary course of events express themselves and have greatest character in physical terms. They very naturally include children, animals, athletes, men at their craft, primitives, and the like.

Naturalness or spontaneity is of course the best guarantee of the variation requisite for living interest. It is the guarantee that actors in the Garrick dictum shall act "with their legs also"; a dictum which from being of secondary importance on the stage becomes of first importance on the screen. It may be doubted if it has ever been possible for actors to pass into other characters to the extent of carrying the new character into the more subtle rhythms and mannerisms of their bodies; and indeed the stage focus on voice and words made it unnecessary. Where the point of focus is altered, and every movement tells in the sum of effects under the visual searchlight of cinematic conditions, the slightest falsity or the slightest deadness is apparent.

In the first case as in the second, the uselessness of stage methods is apparent. The trouble with stage props and acted parts is that they tend to be visually shallow, and all the theatrical emphases in the world, be they as violent as the emphases of Meyerhold or of Lang only make it more apparent that the final source of visual personality and visual drama—the subtle uncontrollable nuances of movement to which in ordinary life one need not or does not pay attention—has not been drawn upon. The age-old native dance in "Moana" has a cinematic power which is unequalled by any staged efforts. The easy magnificence of "Nanook" handling his Eskimo spear, or the eagerness in the kill and the delight in eating which the hunger focus of his race has instilled in him, subtly defy the imitations of a mere performer.

Nothing in a word is so dramatically powerful for the camera as those characteristic gestures and rhythms of physical expression which long necessity has developed and time worn smooth. So far producers have understood this only superficially. They have "naturalized" studio production to some extent, but have not realized the rich sources of cinema material which lie outside, among the natural rhythms of every-day life, among the natural rhythms which spell the character of cities, of occupations and peoples. This, however, leaves the more for other producers to do. In a sense, cinema has not begun to draw on its richest sources.

These considerations are of some importance for producers. They might prevent a repetition of certain errors of the past in the choice of personnel and dramatic material, and they might prevent any tendency to admire the continental model overmuch. But I do not insist on this point because, whatever its faults, American pro-

duction has led the way to the natural, and no one shall say it has not been objective and non-intellectual. Despite the uncritical atmosphere in which it has developed, the American feeling for the open air and for action, and the hatred at the box office for things artificial and introspective and morbid, have combined to lead the American tradition of cinema aright. Pictures like "The Covered Wagon," "The Vanishing American," "The Iron Horse," "The Big Parade," "What Price Glory," etc., etc., and cinematic stars like Fairbanks, Pickford, Swanson, Vidor, Adoree, Dix, Coleman, McLagen, etc., indicate its essential rightness. Even the Russians, who might be expected to approach cinema with the same preoccupations as the Germans, have been very conscious of the superior naturalness of American cinema, and their latest efforts (if rather more intense) are in the American manner. They too have gone outdoors, and they too have realized cinema as a medium of action and spontaneity.

The fault of American cinema, indeed, is not in the central principle which guides it but in its failure to supply the necessary refinements of that principle.

While talking of the love theme and the adventure theme in the first section, I have hinted at one or two of the refinements which are possible in the naturalistic tradition. The American failure, such as it is, is largely related to a shallowness in visual imagination. I indicated how this appeared in the visual crudeness of love scenes, and in the triviality which so often accompanied efforts in epic.

As a general rule, American pictures do not talk back into the environment enough; they do not play on it, light it up, set it moving, intensify it enough, so that it really enters into the story and adds its visual character to the story. American production has had its mail robberies and its train robberies, its railroad smashes and its shipwrecks, its desert romances and its subway romances, its heroes of the steel mills and its heroes of the fire brigade, and it has had its adventures north, south, east and west all over the earth ball, wherever there was a pretty ankle and a scarlet giggle to give them a fade-out. It has covered much ground, and more than a wisp of modern life and energy has crept through. But excepting in some half a dozen pictures ("The Covered Wagon," "The Iron Horse," "The Vanishing American," "Moana," "Nanook," "What Price Glory," "The Big Parade," "Beau Geste," come to my mind) I doubt if the real cinematic essence of life and energy has been caught. There are stories—the Lord knows there are stories—and heroes and

heroines, and romantic clinches, and shootings and dyings, and sudden deaths, and frantic escapes. But I doubt if the guts of reality is in many of them: of the reality which would make the fade-out significant and the adventure really important. I look almost in vain for the cinematic reality of discovery and exploration and colonization, of the sweep of commerce and the dynamics of industry, of ships and docks, plains and plantations, factories and furnaces, streets and canals, dams and bridges, of trades, of professions, of cities, of peoples. The story (as often as not) slithers through to the lolly-pop fade-out, without catching fire at the real source of visual energy and cinematic character.

The world of cinema still awaits a proper handling of epic material. The two countries which have tried to make pictures of the epic sort—America and Russia—seem to be prevented from going far by the nature of their approach. American producers are so bound up with what they call “human interest,” and so insensitive to the dramatic importance of scene and setting, that in most cases they allow the more private preoccupations of their characters to destroy the sweep of events. They are slow to realize that in epic cinema the event, whether it is a struggle of war or a struggle against the odds of nature, must properly dominate the personal aspects of the story and indeed be the tide on which the characters are carried.

It ought to be obvious too that in epic cinema certain impersonal agencies may be very easily and very powerfully exploited. The visual character of a ship or a street or a city or a mountain pass can be built up till it becomes an effective motif in the picture, bringing it into the world of greater and more primitive energies and giving it size and intensity and power. But this too American producers have generally failed to recognise. In a recent picture which professed to recount the historic adventure of an American frigate in Mediterranean waters, neither did the ship live nor did the adventure. The development of larger lives and greater events was lost in a petty sequence of fo’c’sle jests and sentimental amours.

Or take the case of “The Vanishing American.” “The Vanishing American” had a great story: there is no greater story than the passing of the Indian. And it had a great setting: it had the desert, the canyons and the plains to conjure with: it had the night rain-gods and the night luck-gods to conjure with. It began finely. The Valley of Vanishing Men took hold of the spectator and gripped him from the beginning. The primitive races came out from the rocks, they

built their cave houses, they fought and were beaten. The Indians rejoiced in their victory; the Spaniards came and the horses and the muskets; the advancing American of the new era came, and the soldiers, and the artillery. That was noble stuff. There was something of the wilderness of space and of the infinity of time written on it, that took one's breath away. The whisper of the winds of history was on it. But something failed at that moment. The last episode was the twentieth century story of how grafters took advantage of the Indian and stole his lands and how the twentieth century Red Man (Dix was amazing) loved the little schoolmistress. But how cheap and how trivial they made the story after that! The punch of the picture faded, the dignity of the theme vanished, the story lost the atmosphere of the valley and the sense of fate and became like any other story of gentle, gentle heroines and nasty, nasty villains.

The Russians, to take "Potemkin" as a guide, have gone to the other extreme. Communist interests have made them somewhat blind to personal themes and Trotsky's notion that the "apotheosis of the ordinary facts of personal routine becomes unbearable in an age where mass and speed are making a new world" finds its cinematic expression in an emphasis on crowds, ships, streets and factories to the almost complete exclusion of individual life.

It remains for any producer who cares to combine the good elements of the Russian and American schools, and avoid the faults of both. "Potemkin" shows a marvelous capacity for orchestrating the visual details of a cruiser and a mob and making them both gigantic cinematic characters. In this the picture is unique, and technically very far in advance of any other production. If this advance were understood and the method used in conjunction with a greater feeling for story, the combination would be a powerful one.

The secret of advance, as I have suggested, is that producers should appreciate more and more the value of the environment of the story. The environment must be more than a back-drop; it must be, itself, dramatised cinematically and treated imaginatively, so that the story may draw sustenance and intensity from it. At its lowest level this may involve supplementing the obvious embrace of a meaningless amour with a visual play on water, or trees, on meadows, on machinery, which expresses the mood and imaginatively articulates the situation. (In Vidor's "Bardelys" one of the most beautiful love scenes ever staged was effected cinematically by a play of willows and shadows and sunspots as the lovers drifted down the bank of a

stream. In Von Sternberg's "Exquisite Sinner" the romantic atmosphere of a gypsy wagon and life in the woods was used charmingly to express all the feelings of the dramatis personae. There are other instances: but too few.)

At its highest level, the dramatic use of environment would involve a cinematic exploitation of the intenser energies and deeper meanings of actual scenes and living people. It would involve a recourse to natural sources and a great deal more in the nature of expeditionary cinema than has as yet been attempted. Producers send their companies on location but it is a question whether in any real sense of the phrase, they send them far. Production seldom loses the atmosphere of the studio: indeed there are some who claim (Flaherty of "Nanook" and "Moana" is one of them) that it never does. No great attempt for instance is made in the case of pictures with foreign settings to add to the story the rich dramatic values of genuine native life. If the natives are used at all, it is as novelties in the background, as back-drops in a Hollywood illusion, adding a certain picturesque quality to the story, but seldom adding substance to it. Nor is any great attempt made to add to a story the cinematic essence of actual scenes and actual activities. In one very notable instance—"Men of Steel"—an American producer did begin to do this: he exploited the resources of the United States Steel Corporation, and made his picture in Pittsburgh and on the docks on Lake Erie. Some of us waited, foolishly expecting great things. The exception as it turned out, only proved the rule. The cinematic possibilities of the steel mills and the ore ships were not realised at all: the cinematic possibilities of workmen caught in the rhythm and roar of living industry were not guessed at. The director's camera was trained on the living center of modern masses and modern energy with the twentieth century and Western civilization at its feet, but his heart was back in Hollywood. He was in fact too busy telling his hokum story, to incorporate the enormous drama of the life about him, superior as it undoubtedly was from every cinematic point of view. He missed what might have been splendidly popular for what was only tawdrily titivating.

It will be realised by this that the problem of future production is not so much a problem of setting as a problem of using it: using the setting cinematically, shooting the romance out of it rather than imposing the romance on it. Producers have varied their subject matter aplenty: but they have not changed the cinematic grip of

the subject matter. The scene may be new but it is only included in the sense that it provides a fresh back-drop for the same old story. "Men of Steel" does not mean that the story of steel and the heroes of steel thunder their way across the screen: not a bit of it. "Men of Steel" merely means that another professional hero has melodramad his way to another professional heroine with Pittsburgh views in the distance. Cinema in other words has not reached out to the new material and taken it to itself. It has not been inspired to new combinations of visual effects, of tempo, of rhythm: it has not ripped its way into the dramatic intensity of labor and life for the purposes of its story. And it has failed to do this though the greatest box office successes of cinema have been achieved in no other way. A cinematic handling of swinging trapezes meant a great deal to "Variety," a cinematic handling of the desert meant not a little to "Beau Geste," a cinematic handling of wagons and plains meant much to "The Covered Wagon," and of wagons and marching troops to "The Big Parade," and "What Price Glory." It gave to each of them more elemental energy and a visual character more vivid to be attached to cinematic essences in this way.

I may be able to suggest where the trouble begins. As I write this, there has come into my hands a scenario written by the most celebrated scenario writer of Hollywood. I read it over and I was, if anything, more fascinated by it than by any story in a twelvemonth. The ability shown in the mere telling was of a high order: the characters were clear, there was action, clever situation, suspense, more suspense, and there was comedy relief. A lady (a pretty lady presumably) lived as a king's mistress, her heart was with the people, she loved an artist, but in the end she hesitated between the pearls of great price and the things which are supposed to be greater than these; and in the dilemma she lost. The story itself does not matter however: I merely wish to insist on the excellence of its execution as a story. The only thing indeed that was at all lacking in it was cinema. I do not mean to suggest that the story was not told visually: it was, and scene followed scene with scarce a sub-title, developing the plot and bringing out the interplay of character. My point is that the story could have been told as well in novel form or in drama form: it had nothing in it that specially exploited the possibilities of the medium in mass, energy, movement, and in spontaneity. Scenes at court, scenes in the garden, scenes in the pavilion, scenes in the local tavern, deceptions, hidings behind curtains, conspiracies, escapes:

there they all were just as they might be on the pages of any romance. All the camera was commissioned to do was to follow the characters from place to place (with an appropriate sense of the intimate) and watch them doing this, that, and the other thing. The suspense of the events and the smart novelty of the situations were in complete charge.

A picture of this nature is of course limited from the beginning. It is of necessity an artificial or theatrical picture with its courts, and its costumes, and its unnatural roles, and the camera's love for authenticity has no great opportunity to show itself. But the point is not vital because there must always be a demand for unreal pleasantries of this sort, and cinema undoubtedly will go on relieving one of the labor of reading them. A more important consideration is that the scenario form when it has too much of a story focus, tends to starve the camera at its vitals. When the producer handed me the scenario, he described it strangely as "fool-proof." All you have to do with a scenario like that, he said, is to look and shoot. Now I wonder. Is it really possible to *write* a picture in this way? Is it enough to have the situations and the sequences and the story arranged? Is it not precisely this very writing of pictures which has been responsible for half the cinematic deadness of pictures in the past?

The point is that the scenario with a story focus is only the beginning of cinema. It may be very prettily hung together for camera treatment, and even full of human interest, yet avoid all those special cinematic effects which give punch and atmosphere and variety and loveliness to the screen version. A scenario proper ought to be a double barreled affair at the very least, with one column for the sequence of events, and a second (a much larger one) for the cinematic treatment, with appropriate details concerning tempo, imagery, composition and the like. But even then cinematic effects are so much the secret of the camera and so much the secret of the locale that it is doubtful if they can be prepared cold beforehand.

I am merely suggesting a change of focus from the point at which people emphasize story sequences and think up environments for them, to the point at which people emphasize the cinematic power that may be taken from environment and think up a story to give human significance to it. I feel that the cart has been put before the horse in cinema, and that the true source of cinema drama (the world of movement and spontaneous behaviour) is not being drawn upon as much as it should be. There is a real difference

of attitude involved. Lately I found myself arguing with an English cinema producer. He told me of a plan he had for a picture. Wife—husband—other party . . . as in "Variety" . . . he went on. I asked: Where is the source of visual energy and visual gaiety? . . . where the trapezes? . . . and the side shows? He had not thought of them!

It is clear of course that the argument leads finally to an analysis of how imaginative visual effects are to be got,—of how effects of tempo, composition, imagery, and the like, can be built up to the greater visual glory of a picture. Any extended discussion of better pictures would have to undertake this analysis and show specifically in what directions visual imagination can be given greater play. I shall leave these matters however for another occasion. I am content for present purposes to suggest that—within the limitations of popular demand—the greater play of visual imagination is possible, and even desirable.

Another Hyper-sensitizing Process.—Two Berlineses (Germany) investigators, Moise Safra and Reimar Kuntze, have it is announced, made a wonderful discovery by means of which an interior set may be taken by the light of a single incandescent lamp. For outdoor work it enables one to take dark woodland scenes, late evening and night effects. This wonderful result is attained by passing the film through a certain chemical bath. The only disadvantage is that the film must be used within a month; "but it is hoped to overcome this defect as preliminary experiments have proved this to be possible." According to the inventors excellent results have been secured of a group illuminated by red light only. (*Le Cinéopse*, 1927, 9, 340).

Silver-free Oza Film.—This is a positive film prepared with cellophane, a derivative of viscose. A positive is obtained from a positive and so far only red and dirty violet images result. A mercury vapor lamp must be used for exposure and development is effected with ammonia vapors. It is stated that the images can be toned and dyed and its price is one-third of the ordinary celluloid films. (*Film-technik*, 1927, 3, 149). The description would lead one to assume that the Kögel-Kalle patents—U.S.P. 1,444,469; D.R.P. 302,786; 371,385; 386,433; 383,510; 386,434, are used.

FILM CARE IN THE TROPICS

BY HERFORD TYNES COWLING*

THIS paper describes the use and care of motion picture negative film which is to be exposed in tropical countries and far away from the home laboratory.

The immediate action of light on sensitive film is the production of a latent image and an invisible picture which can only be made apparent by the process of development. With modern materials the camera man knows that a certain exposure in a certain light with the appropriate lens aperture will produce a definitely predictable amount of latent image which when developed, either today or tomorrow or next week will yield a picture of equally predictable intensity. He can rely on the latent image enduring unchanged until he wishes to secure its development.

It is a little realized fact, perhaps, that under abnormal conditions of heat and moisture, especially in those hot countries where bacteria and fungoid moulds abound, the latent image is not quite so permanent as we are wont to believe. Little by little as each week passes in the traveler's journey towards home, the latent image may become weaker until by the time the film reaches the laboratory only a very feeble picture can be revealed by development.

My own personal experiences in tropical countries, especially during the humid rainy seasons, has shown that there is generally a pronounced fading of the latent image together with much general fog on development unless certain definite rules are followed. I have found it advisable to treat the problem from two angles. Firstly, it is wise to increase the camera exposure so that there is more latent image to withstand fading; secondly, a scheme of packing must be employed which ensures protection against these harmful atmospheric conditions. By adhering to a few common sense rules I have found it quite feasible to keep negative film from a minimum of four months to a maximum of nine or more (depending on conditions) between the exposure and the development. One lot of 3000 ft. exposed in Sumatra, under the grueling heat of the equator, did not arrive home till ten months later, but owing to judgment in exposure and care in packing there was very little which was not of excellent quality.

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We may divide the life of negative film into four periods; that which elapses:

- (1) Before opening the sealed unit which comes from the manufacturer;
- (2) Between opening the unit and placing the film in the camera;
- (3) While the film is in the camera;
- (4) Between exposure and development.

1. *Care in Shipping and Before Opening the Original Container.*

Negative film is comparatively safe from decay whilst resting in the original metal container in which it comes from the manufacturer. When once this has been opened, even though it be immediately resealed with tape, moisture and bacteria have been admitted and the film's future history becomes a matter of doubt. Experienced travelers and explorers adopt a unit system of packing and avoid opening any of the film as originally packed until required for use. Among the items to be specified when the negative film is ordered from the manufacturer the following are important:

- 1—Type of camera in use;
- 2—Length of rolls required;
- 3—Method of winding peculiar to the particular camera in use;
- 4—Kind of negative desired; (Par-Speed, Super-Speed, or Panchromatic);
- 5—Size of unit packing desired;
- 6—Number of rolls of adhesive tape and black paper required.

The unit system of packing employs a series of three containers, each larger unit containing a number of smaller units as follows:

First Unit: This should hold the length taken by the camera, whether 50-100-200 or 400 ft. rolls, sealed, double-taped, original metal containers as supplied by the manufacturer.

Second Unit: This should comprise 5 first unit rolls placed in a larger metal container and hermetically sealed with a very thin sheet of *soft metal* to allow for opening with a pocket knife. An additional double-taped cover should be provided so that the second unit can be used for repacking the first units after exposure.

Third Unit: This consists of a metal-lined, wooden shipping case containing 4 to 6 Second Units. The sealed metal lining can be taken out of the wooden shipping case and put into fiber cases or other carriers for local transport without opening the metal. Maximum weight, not including wooden shipping case is forty pounds.

A supply of one inch width adhesive tape in rolls sufficient to double tape all the first and second units after use, also new black photographic wrapping paper in a sealed roll sufficient to rewrap the film, should be included in this unit.

The larger unit may also be used to pack other photographic supplies used on the trip, including plates, film rolls, etc., and which may also be wanted on the unit system. Photographic supplies should be kept separate from any unit containing other supplies.

Shipments to agents or representatives in foreign countries should be accompanied by strict instructions to store in a cool dry place: In this connection it is advisable to call attention to the fact that the medium of transportation known as *Express* in the United States is peculiar to the United States and Canada alone and does not exist in other countries. Consequently goods shipped by *Express* from the United States becomes *freight* at the port of embarkation and moves as freight upon arrival in and during railway transit through any foreign country and freight moves extremely slowly: The term "Goods" is used instead of freight abroad. This is very important when shipping perishable goods.

The best way to supply film for any expedition, is to have it shipped to the nearest shipping point by the manufacturer well in advance of need. Otherwise take it as baggage, though there are some complications and important things to know about the latter.

All film is subject to custom duty charges in every country and custom officers are not everywhere familiar with the sensitive nature of film, resulting in their often opening a few cans to determine the nature of the goods. Also nearly all steamship regulations require that all films go as deck cargo and prohibit their presence in the baggage room or cabins. The best place for cases of film on a steamer, if prohibited in the cabin, is in some sheltered position on the deck where it can be kept cool and dry. It is inadvisable to store film near the engine room where it will be subject to heat and violent vibrations, nor should it be put in the ship's refrigerator, as this is entirely unnecessary. It is not necessary to use any hygroscopic chemical for the assumed purpose of maintaining a dry atmosphere with the containers; indeed this is a dangerous and messy procedure.

If negative film is specially packed by the manufacturer for export and care exercised in transporting, no fear need be maintained for its safe keeping qualities.

Par-Speed negative film specially packed for me by the Eastman Kodak Company, as described, has kept in perfect condition for over two years and withstood varying changes of temperature and conditions of travel through Central Africa, India and around the world on my various expeditions, without any loss.

Another item to be noted in taking motion picture film as baggage is that all ports of England prohibit any motion picture film being brought into England as baggage, and regulations there impose a large fine for offenders. This does not refer to the question of custom duties, but is an arbitrary rule against entering England with moving picture film as any type of baggage, either hand baggage or in trunks. The only way to avoid trouble at an English port is to list the film cases on your steamer as ships cargo and have it placed on the ship's manifest. The fact that film is "left in bond" in a port does not affect this rule. This rule does not exist in any other country but applies to all ports of the British Isles.

All film, whether manufactured in the United States or not, is subject to a custom duty charge upon return to the United States if it has been exposed abroad.

Care should be exercised to avoid taking film through several foreign countries in baggage, as custom duties are demanded in *each* country. Few countries have arrangements for baggage to be checked through transit "in bond" and demand that custom duties be paid on a "refund basis." Such procedure takes months of delay and is decidedly impractical. Films should therefore be shipped direct to the nearest shipping point to destination whenever possible.

Under conditions customarily encountered in local transportation where goods are transported upon backs of coolies, pack animals, etc., they are subjected to considerable jolting as well as changes of temperature and weather.

During the rough travel the third or larger units should be protected by wrapping, with both a straw-matting and a cheap waterproof cloth tied with rope. In the absence of straw-matting it is well to use the cheap red cotton blankets, obtainable in the native bazaars, as an inside wrapping. These coverings serve as protection against vibration, moisture and extreme heat.

In extremely hot climates, like Central Africa, and on long marches in the sun, the waterproof should be wrapped inside and the package kept cool by occasionally wetting the outside straw-matting cover. The rapid evaporation keeps the temperature down. Care

should be exercised to see that porters do not leave their loads containing these units directly in the sunshine unnecessarily for long periods during the heat of the day.

2. After Opening—Before Exposure

Negative film should not be rewound before using in the camera if it can possibly be avoided, as the emulsion thereby absorbs moisture from the atmosphere during the rewinding. This also allows foreign matter, such as very fine dust to settle and adhere to the surface as a consequence of the electrification of the film during rewinding and this will ultimately cause minute spots on the picture after exposure. Also "static markings" are likely to result from friction that is developed in the rewinding operation.

It is well to open only one of the third or larger unit containers at a time, carefully protecting the contents from moisture. The best time to open these units is at night when it is often cooler than during the day. Heat has considerable effect on the film emulsion in the presence of moisture, so that changing in a moist atmosphere should be avoided whenever possible.

As soon as the film has been taken from the inner first unit or original container, as it was sealed by the manufacturer, it begins to spoil at a rapid pace and continues to do so until it is exposed and developed. Thus care should be exercised not to load film into the camera magazine any earlier in advance of use than possible. A good spacious light-tight changing bag such as the "Ingento" is most essential for this purpose and will allow for quick loading of the film rolls into magazines just prior to use as well as temporary re-packing very soon thereafter.

The greatest dangers to be avoided after loading in the magazine are the absorption of moisture from the air and friction from transport vibration. The film is naturally free in the camera magazine and although wound tightly in a roll to exclude all possible air from entering when packed, as soon as the tension of the wrapping is removed it will "loosen up" in the roll. This "loosening up" allows access of atmospheric moisture and heat to the emulsion surface and at the same time the coiled layers of film slide from side to side upon each other, thereby developing minute friction markings. This is, of course, true both before and after exposure.

Film loaded in magazines and transported for some time in motor cars over rough roads and on trains invariable loosens up and develops minute friction or "rain streaks" from vibration.

This trouble can be considerably lessened by wadding the black paper, in which the film is originally wrapped, inside the camera magazine so as to wedge the film roll tightly and thus prevent "loosening-up," but, of course, the black paper must be removed from the magazine by the use of a light-tight hand-changing bag before use in the camera.

It is also advisable to use waxed paper to wrap camera magazines loaded with film, when they are not sure to be used the same day as loaded, to prevent moist air from passing into the magazine both before and after exposure.

When working near salt water additional precautions against exposure to the atmosphere should be taken owing to a more rapid deterioration of the film emulsion from contact with the chemicals which are carried in suspension in the air.

3. *Exposure in the Camera*

Correct exposure in the camera depends, in a large measure, on the approximate time interval that must lapse before development. If the film is to be developed in the field or shortly after exposure, say one to two weeks, normal exposure is sufficient and there is no definite rule for an increased exposure ratio in anticipation of delayed development.

Exposure meters are invaluable as a basis for ascertaining the correct exposure for immediate development, but no allowance is made for the lapse of time during a delayed development interval.

4. *After Exposure and Before Development*

After negative film has been exposed in the camera, it should be repacked with black paper and taped in the original first unit container, as soon as possible without rewinding. Often it is not practicable to do this packing with the necessary thoroughness during field operations. The films must then be placed temporarily in the tins until a dark room is available and a number of exposed rolls have accumulated, and until drier condition of the atmosphere prevails.

The thorough final packing of negative film after exposure referred to above, for delayed development and transport, should be conducted in a dark room if possible, although it can be done in a light-proof changing bag. The old black wrapping paper, wooden spool or core, and tape, which came in the original package, should be entirely discarded and fresh black photographic wrapping paper

and fresh adhesive tape used. Never use newspaper or any kind of wrapping paper other than black photographic wrapping paper to repack film, as most paper contains chemicals injurious to the sensitive film.

The original containers should be well dried out with the flame of a candle to remove all moisture. The film roll must be drawn as tightly as possible without "pulling" and wrapped tightly with the new black paper. After placing the film inside the dried container, the center opening and every possible space available, is filled tightly with dry, fresh, black paper. When the cover is placed on the container under pressure, it should exclude all possible air from the container, and a double wrapping of new tape should be tightly drawn around the cover edges to seal the container. The tape should then be sealed over with a coating of hot paraffin wax, for which purpose melted candle wax will serve very effectively.

The original container should then be repacked in the inside second unit containers, in the same manner, after which the film is ready for shipment to the laboratory for development.

All of the same precautions as mentioned under "care before exposure" should be even more carefully observed after exposure, as the film is now more susceptible to injury than before exposure.

Field Development^{1,2}

It is more practical to utilize the delayed development method of operation than to attempt field development of motion picture negative film except at considerable expense, and by expert handling. Developing motion picture negative film by the use of portable equipment in the field requires considerable care and skill. But, whenever possible, it is advisable to develop short-test strips to determine the correct exposure; which exposure can then be increased for delayed development.

¹ "The Handling of Motion Picture Film at High Temperatures," by J. I. Crabtree, Trans. Soc. M. P. Eng. No. 19, 39.

² "The Development of M. P. Film by the Reel and Tank System," by J. I. Crabtree, Trans. Soc. M. P. Eng. No. 16, 163.

A NEW PROCESS FOR DEVELOPING AND PRINTING PHOTOGRAPHIC SOUND RECORDS

J. B. ENGL*

AT THE present time quite a number of different methods are known how to record and reproduce sound waves for the purpose of the so-called talking film. With most of these methods the sound variations are photographed on a moving film-strip. Corresponding pictures and sounds being recorded on one common carrier, the synchronized reproduction of both picture and sound records can never be questioned.

These methods of recording (I only mention here the names of different systems: Tri-Ergon, DeForest, Case, etc.) are a great advantage compared with the old method of recording the sound waves on a phonograph-disk and synchronizing the rotating phonograph-disk with a moving film-strip by means of special, more or less complicated machines.

These photographic recording processes have all in common a combination of a microphone, an amplifier, and a light source controlled by the amplified microphone currents. It is assumed and is to be proven that the intensity of the light source is varying with a linear function of the intensity of the sound-source.

The light variations are photographed on the film-strip and appear after developing as density-variations, more or less transparent parts arranged in a so-called step-ladder-pattern. Positive prints from the negative are made, and used in the reproducing machine to generate photo-electric currents in photo-electric cells which are expected to be strictly proportional to the original light variations of the glow-light.**

Now it is known, that densities produced by exposing a light-sensitive emulsion to light and developing it have not a simple relation to the original light intensities used in the exposure.

In Fig. 1 a graph is shown where different intensities of light acting upon a light-sensitive emulsion are plotted against the values of produced density. There is only one portion which is practically a straight line, and which corresponds with a range of normal exposure. Below and above this straight line portion the curve is bent.

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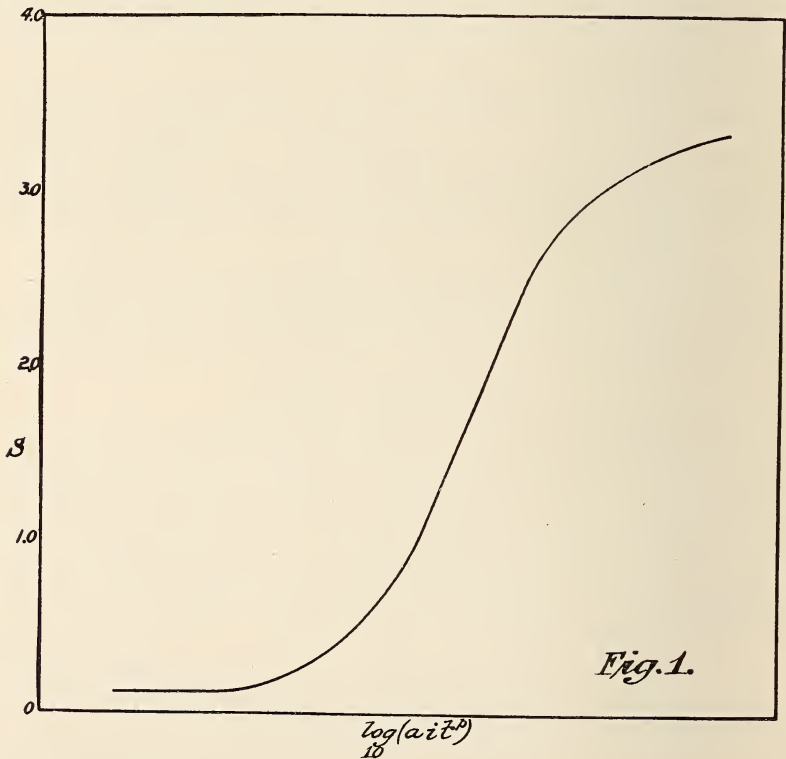
** A light source of the Geissler tube type.

Abscissas are plotted to the logarithms of the illuminating intensity, ordinates are the so-called densities S . The values for S are defined by the following formula:

$$S = \log_{10} \frac{J_0}{J} = \log_{10} U \quad (1)$$

$$U = \frac{J_0}{J} = 10^S.$$

U is called the opacity of the developed film as measured by any photometric arrangement.



J_0 is the intensity of the light-ray, which is used in the photometric work and which impinges on the film-strip, J is the intensity of the light-ray after passing through the film-strip. A similar formula is valid for the positive emulsions. The curve of Fig. 1 can be divided in three parts. The beginning being curved corresponds to small illuminating intensities, the middle portion, which is almost

a straight line, gives the range of normal exposure, and the upper part of the curve corresponds to an over-exposure.

In the reproduction of a photographed sound-record, a light-ray is passed through the positive print which is run through the machine. By special optical systems a brilliant light-line is focused on the film. After passing the film, the intensity of the light-ray is more or less diminished on account of the opacity of the print, which varies at different points of the print. As the film-strip is moving with a constant speed, the intensity of the light-ray is varying around an average. The light-rays falling on a light-sensitive electrode of a photo-electric cell create there alternating electric currents. For reproduction purposes it is preferable to have as large photo-electric currents as possible, the photo-electric currents being normally only a few microamperes. Any increase in current intensity is valuable. The amount of light passed through the film varies around an average, going from zero, meaning absolute opacity, to a maximum of absolute transparency. The average, therefore, should be just 50% of the light-intensity which is passing through the most transparent points of the record. Absorptive powers of about 50% are located in Fig. 1 in the beginning of the curve. Hence it is clear that there cannot be any proportionality between photo-electric current and intensity on account of the curvature. Doubtless, the characteristic curves of the recorded sound waves must be distorted in the reproduction. It is not possible, therefore, without special methods to get an ideal quality of sound reproduction.

In the negative record we have not necessarily to use as small densities as in the positive print. For the printing process itself the density of the negative is not of great importance as we can easily increase either the printing light or decrease the printing velocity. But assuming that we are utilizing in the negative record the straight line portion of the curve, we can not get rid of the distortion caused by the above explained properties of the positive emulsion. In the following I give a method of developing which overcomes this difficulty. The idea is to develop the negatives in such a way that an artificial distortion is created which compensates the distortion made in the positive print. It is possible to develop so that the deviations from a straight-line-characteristic in the positive print are just compensated by analogous deviations in the negative record.

Before I show how these final results were obtained, I will explain how the results by the different developing processes were

tested. In Fig. 2 results with different developing baths and with emulsions of different properties are graphically represented. Looking at the curves in Fig. 2 we see that an appreciable distortion exists, caused by the above mentioned properties of the photographic emulsion. As abscissa currents flowing through the glow light are plotted, as ordinate currents flowing through the photo-electric cell.

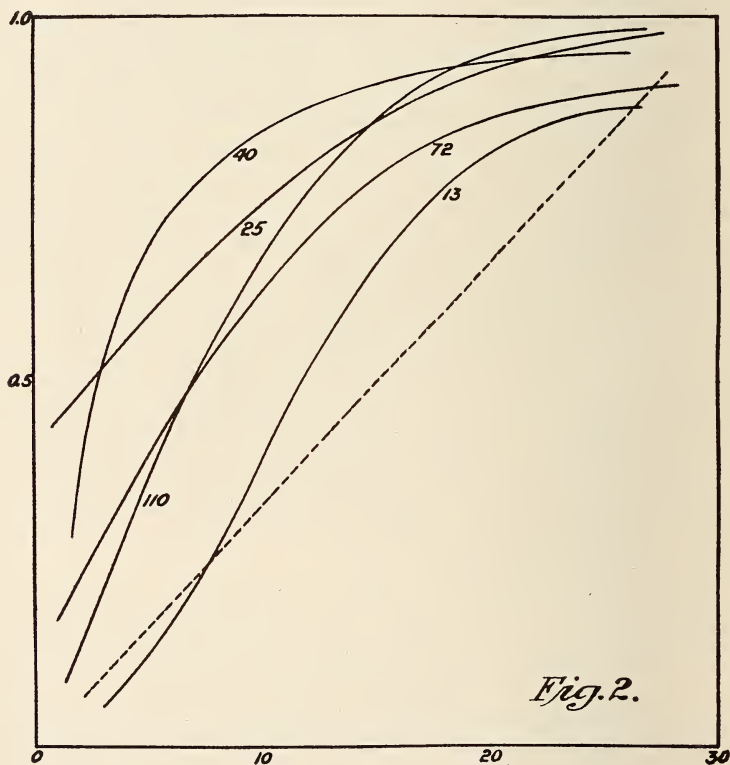


Fig. 2.

The densities were measured in the following way. One film-strip was run with constant speed through the recording camera. The moving film was illuminated by the glow-light. The intensity of the glow-light was varied during the running of the film with the intention to expose the film to several known illuminating intensities. The currents which corresponded to those glow-light intensities were measured before and after exposure with all precautions concerning the constancy of the glow light current.

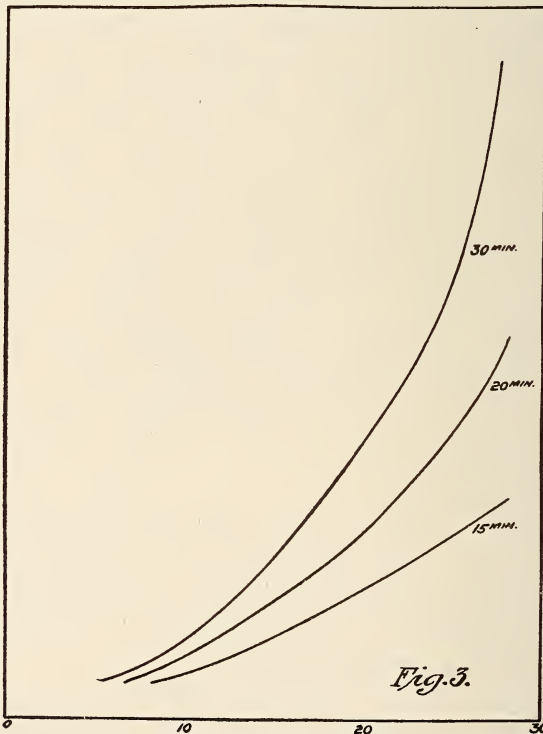
In order to get the different glow-light-discharge currents the glow-light tube was connected in series with the plate circuit of the amplifying tube. By changing the grid potential of the amplifying tube by means of a potentiometer device between cathode and grid it was possible to get a series of known glow light currents. Of course, the voltage of the plate battery had to be exactly the same during the recording of the density marks which were to be compared later on.

These density marks were printed on strips of positive emulsion. They were developed for a definite time, in a developing bath of definite composition, and of definite temperature. After fixing and drying, the densities of the corresponding marks on the positive strip were measured with a photometric arrangement. This consisted of a photo-electric cell, an optical system with which a small part of the density mark was illuminated and a light source of constant light intensity. A diaphragm of small aperture allowed only a small part of the density mark to be illuminated. The illuminating light-source was a tungsten lamp with a small strip-shaped filament. The voltage in the tungsten lamp circuit was smaller than the normally allowed voltage in order to be sure of a constancy of light-emission for a long time. Constancy of light-emission was controlled by measuring the energy consumption, holding the current with an ammeter and the voltage between the lamp terminals constant. The tungsten lamp was lighted always a sufficient time before it was really used for measurement.

The photo-electric currents were measured with a high sensitive galvanometer in the cells' circuit together with a constant battery voltage of 50 volts. As the constancy of the light-sensitivity of a photo-electric cell, measured by the currents, depends on the voltage between the terminals of the cell, the constancy of the battery had to be controlled during all measurements.

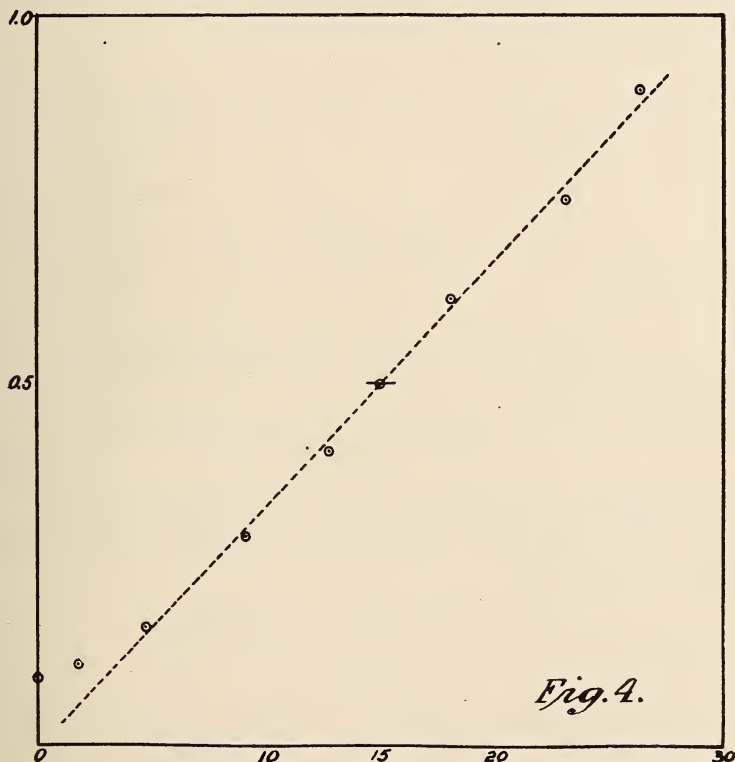
The curves of Fig. 2 show that there is no proportionality whatsoever between the glow-light current and the photo-electric current. The curves represent only a small number of the measurements of several series of density-marks made under about 30 different conditions. The dotted straight line in Fig. 2 shows which relation between glow-light current and photo-electric current is desired. The shape of the curves represents, more or less, the beginning of the known "S" shaped curve which is given in Fig. 1. The dotted line in Fig. 2 shows that a glow-light current of 15 *MA* should correspond to a photo-electric current of 50% of the maximum

photo-electric current. The current of 15 MA in the glow-light tube was the average current which was modulated above and below its value. The smallest glow-light current should produce a value of $J/J_0=0$, maximum the value of $J/J_0=1$. It may be mentioned that all the values J/J_0 are reduced by the value of the fog density as well as by the absorptive power of the celluloid base. The value J_0 corresponds, therefore, to the light intensity after passing through the celluloid base and the fog density.



The curves of Fig. 2 show that the transparency of the positive marks does not increase with increasing glow-light current in the same ratio. Transparency of positive marks means opacity of negative density-marks. The problem was to have the opacity of the negative density-marks increasing with increasing glow-light current at least in the same ratio as at small glow-light currents or with a greater ratio if possible. This was shown possible by using an abnormally long developing-time of the negative density-marks.

Fig. 3 gives some curves which show the effect of increasing the developing-time on the density of the negative density-marks. Abscissa is again the glow-light current, ordinate is the value J_0/J of the corresponding density-marks. Three curves are shown corresponding to the developing-time of 15, 20 and 30 minutes in a normal hydroquinone developer. It is apparent that the steepness of the curves increases with increasing developing time and what is most important that by this over-developing process the steepness for



large glow-light currents is remarkably greater than for small ones. Of course, a very dense general fog is produced by the over-developing. It was possible to reduce the veil by using a sufficient quantity of potassium bromide in the bath.

If the negative film was developed in this developing bath for 25 minutes, and if the positive print was developed $4\frac{1}{2}$ minutes in a normal developing bath for positive emulsions, I found a series

of density-marks on the positive print which is shown in Fig. 4. You can see that the curve is as straight as possible. A glow-light current of 15 MA corresponds with a transmission of 0.5. This is correct, of course, only for a definite value of the printing light.

What is shown above as a result of a series of experiments, can be deduced theoretically as conditions, which must be satisfied by contrast-coefficients of the negative and positive emulsions. Following the law of Bunsen-Roscoe and Schwarzschild, we can write the relation between the density produced on a light sensitive silver-bromide emulsion and the light intensity:

$$(2) \quad S = \nu \cdot \log (a i t^p)$$

S —the density defined as above by (1), a is a number factor, i is intensity of illuminating light, t is the time of exposure, and p the parameter of Schwarzschild.

The factor ν is constant in the straight line portion of the curve of Fig. 1, it is variable in the bent parts of the curve. The amount of light which impinges on the negative film during the exposure we can write as:

$$(3) \quad I_n = \alpha \cdot i_I t^{pn}$$

where i_I is the glow-light current during the exposure and α is a proportionality factor.

For the density of the negative, S_n , we get, using formula (2):

$$(4) \quad S_n = \nu \cdot \log (a_n I_n) = \log (a_n \alpha i_I t^{pn})^\nu$$

In the printing process a printing light intensity I_0 may be used; it is weakened by passing through points with a density S_n .

The light intensity I_p acting photochemically on the positive emulsion is therefore:

$$(5) \quad I_p = I_0 10^{-S_n} = I_0 (a_n \alpha i_I t^{pn})^{-\nu} = I_0 (a_n \alpha t^{pn})^{-\nu} i_I^{-\nu}$$

As density S_p in the positive print we get the value:

$$(6) \quad S_p = \pi \log (b_p I_p t^{pp})$$

Here π is the factor for the positive emulsion which corresponds to the factor ν in the negative emulsion, b is a proportionality factor and p_p is Schwarzschild's factor for a positive emulsion.

Using (5) we get for the density S_p :

$$(7) \quad S_p = \log (b_p t^{pp})^\pi I_p^\pi = \log [(b_p t^{pp})^\pi I_0^\pi (a_n \alpha t)^{-\nu\pi} i_I^{-\nu\pi}]$$

The opacity u_p of the positive film is:

$$(8) \quad u_p = 10 S_p = \frac{(b_p t^{pp})^\pi I_0^\pi}{(a_n \alpha \cdot t^{pn})} + \pi \cdot \left(\frac{t}{i_I}\right)^{\pi\nu} \sim \left(\frac{t}{i_I}\right)^{\pi\nu}$$

Measuring the opacity u_p with a photo-electric cell we have:

$$(9) \quad u_p = \frac{J_0}{J}$$

where J represents the photo-electric current generated by the light after passing through the positive film. J_0 represents the photo-electric current created by the light intensity when there is no absorption by the density-marks. Comparing (8) and (9) we see that J is proportional to the glow light current i_1 :

$$(10) \quad \frac{1}{u_p} = \frac{J}{J_0} \sim (i_1)^{\pi\nu}$$

if the product $\pi\nu=1$ for all points of the characteristic curves of positive and negative emulsions which are used.

By the just described method of over-developing the parameter ν was increased on all points of the curves where the parameter π had too small values.

DISCUSSION

MR. HILL: I should like to ask what the resolving power is, that is, how many lines to the foot? Do you not have to stop with loud speakers letting through 16,000? If you have any sound reproducing apparatus in Germany responding to 16,000 you are quite a few cycles higher than we are over here. If you have loud speakers letting through 16,000, you have us stopped; we have to shut off at 5,000.

DR. ENGL: With this process, the upper limit of resolving power is the size of the grains of the emulsion and these vary. One is obliged to use a very sensitive emulsion to obtain enough density on the negative and have then larger grains than in the positive with which I succeeded in recording frequencies of 16,000 per second, which is more than sufficient for sound recording. The upper limit of hearing differs with different human beings. As you know, with increasing age this upper limit goes down, but at your age you can easily hear a frequency of 16,000. Frequencies of 1,000 are reproduced with much better efficiency than those of 15,000, but, of course, something will be heard; especially if electrostatic loudspeakers are used.

MR. TUTTLE: At what speed is the film run to obtain a frequency of 15,000?

DR. ENGL: In these experiments it was about 2 feet per second. The light-line projected on the film was very small—smaller than that generally used for recording sound photographically.

MR. MAYER: I do not think that many of us are familiar with the glow lamp.

DR. ENGL: Glow-light-discharge apparatus consists of a glass filled with gas, with two electrodes sealed in its wall. That used in our experiments has as cathode a metallic rod, and as anode a second thin wire electrode. If there is a difference of potential between the electrodes, the gas between them is ionized and one sees—in the case I speak of the vessel was filled with argon—a bluish light around the cathode. In an incandescent lamp bulb we have a different physical fact. Here there are two seals but between them is a metallic connection and the glowing part has a high temperature and emits a corresponding radiation. In the other case there is no high temperature, but yet radiation. The glow-light-discharge is characterized by the fact that the radiation produced is independent of the temperature of the process. In the carbon arc, there is a high temperature on the cathode. The glow-light-discharge gives a different kind of radiation, which we call a fluorescent radiation. The light of the glowing cathode of the carbon arc is a temperature radiation, depending only on the temperature. The radiation emitted by the glow-light depends not on the temperature, but only on the electric current, which flows through the discharge tube. I believe this is a definite difference between the two kinds of radiation.

MR. JENKINS: Did I understand that you use argon, and do you find that the light follows pretty accurately the current in the potential, the modulation of the current?

DR. ENGL: Argon was used because it gives a strong actinic radiation. The potential depends on the gas pressure. In order to obtain high brilliancy on the cathode one should use pressures of several millimeters of mercury and a potential difference about 500 volts. I have recorded frequencies of more than 10,000 per second. With this type of gas discharge about 200,000 or 300,000 per second have been recorded by others. The modulation of the current is good. A high frequency discharge of a condenser was passed through the tube. If you use two co-axial wire electrodes in a cylindrical tube, a cylindrical glow-light layer is obtained round the wire and this light changes in length when the current is changed. Length variations were recorded on a moving photographic plate. Lines of varying lengths are obtained and one can compute the damping coefficient of a circuit by measuring the decrease of the amplitude of the oscillation. It is equivalent to modulating the high frequency.

A NEW CAMERA PULL-DOWN MECHANISM

GEORGE A. MITCHELL*

THE use of miniatures in motion picture productions, where a part of the scene is normal action, and part built to a smaller scale, especially where there is action in both exposures, has called for a positive acting high speed movement.

In the taking of these scenes it has been customary to employ two cameras, one for the high speed or miniature, and another for the normal takes.

In the photography of animals especially, and other scenes, it is desirable to have a camera which operates as quietly as possible.

The following is a brief description of a movement designed to meet these requirements.

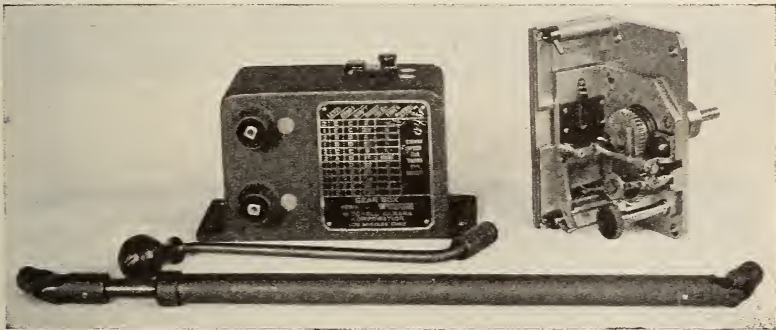


FIG. 1

Fig. 1 shows the movement unit, the gear box, the driving shaft and large crank. The movement is interchangeable in any of our cameras, no machine work being necessary. On the gear box are three places to attach the crank, and two places to attach the driving shaft. On the top of the box is a gear shift lever, and with this arrangement, eleven speed changes are possible, from 2-128 pictures per second, the operator turning the crank 120 per minute, or normal.

The extension shaft centre has a "V" groove on each side and corresponding grooves in the outer casing. These grooves form a ball race, and instead of keys we use balls to drive. By this method no end thrust can be transmitted to the camera.

* Mitchell Camera Corporation, Hollywood, California.

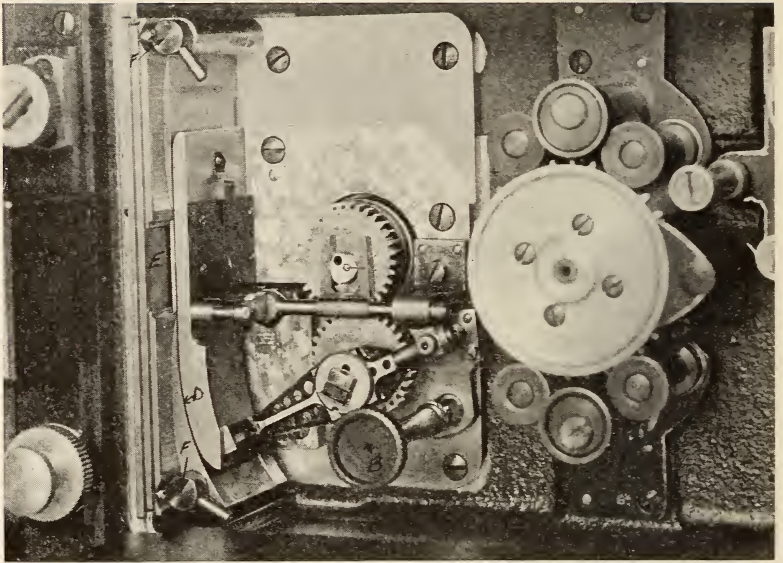


FIG. 2

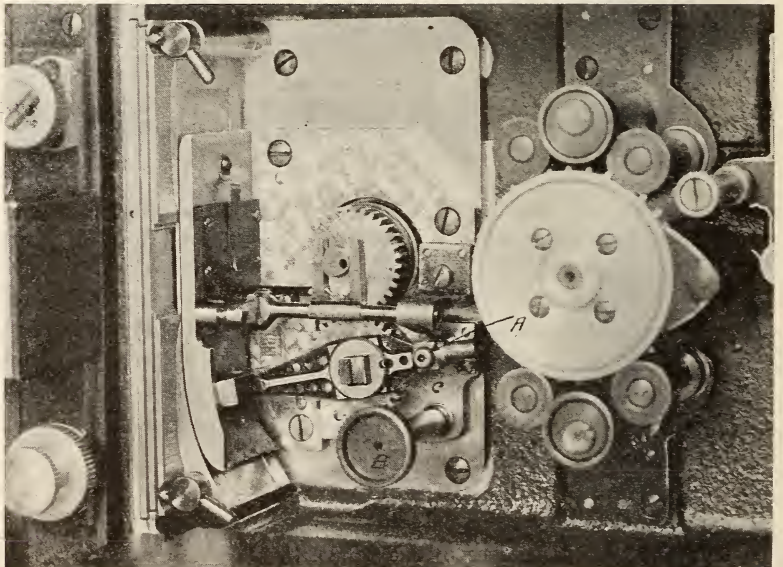


FIG. 3

Fig. 2 is a larger view of the movement mechanism, showing the pilot pins in the film, and the pull-down claws disengaged and returning to the top position. Two claws are used on each side for pulling the film, and the claws and pilot pins overlap, one entering before the other disengages.

The pull-down member slides in part *A*, and pivots at the same point. Two cams of the same design but of different throw operate the pull-down and pilot pins. The pull-down is a curved path approximating the natural curve of the film. To thread, screw *B* is loosened, and bracket *C* carrying the driving gear cam and pull-down arm, is moved to the rear as shown in Fig. 3, while the pilot pins are disengaged, enabling the operator to slide the film in slot *D*.

This slot will accommodate two thicknesses of film for special work, and matting 1/16 of an inch in front of the film may be done at opening *E*. By loosening two clamps, *FF*, the front plate may be easily withdrawn for cleaning. The pressure plate is made with two rollers in the center of the aperture, and two steel shoes over the perforations, so that no pressure is on the picture area. This has a constant pressure of a very light spring. The rollers are made of ebony, with a steel core. The film race is of stainless steel.

DISCUSSION

MR. CRABTREE: In the mechanism described the gate is flat, but I think that with only a slight modification the same mechanism could be used in a printer fitted with a curved gate.

A PNEUMATIC FILM SQUEEGEE

J. I. CRABTREE AND C. E. IVES*

IT IS very necessary to remove all excess moisture from motion picture film after washing and before drying in order to prevent the possible formation of markings during drying.¹ This is especially true if the gelatin coating of the film is abnormally swollen, which condition may exist in warm weather if the processing solutions are not kept at normal temperatures or if the film is insufficiently hardened either before or during fixation.

When developing motion picture film by the rack system it is customary to wipe the film with absorbent cotton, chamois, or sponge during transference to the drying reel,² but this involves the expenditure of a considerable amount of labor and the gelatin coating of the film is liable to be scratched unless great care is exercised in the wiping process.

The most satisfactory method of removing excess moisture from the film after washing is to impinge a blast of air on both sides of the film. Pneumatic squeegees for accomplishing this are in general use on processing machines but they have not been adopted by laboratories using the rack and tank system of development, owing to the non-adaptability of the conventional squeegee for this purpose.

A simple air squeegee having a single pair of air nozzles was first constructed and this produced good results but it did not permit of loading the film on the drying reels sufficiently rapidly. The apparatus was modified by adding a second pair of nozzles working at right angles to the first set and at a distance of about 6 inches away which permitted the film to travel at twice the speed.

A plan of the apparatus is shown in Fig. 1. The wet film first passes over a short wiping table *T* over which a wad of wetted absorbent cotton wrapped around the film is held so as to loosen any dirt adhering to the film. After passing over the idler roller *R*₁ the film passes between the first pair of air nozzles *N*₁, over roller *R*₂ and between the second pair of nozzles *N*₂ and then over roller *R*₃ to the drying reel. Rollers *R*₁, *R*₂, and *R*₃ are necessary in order to keep the film taut between the nozzles, otherwise any variation in the air pressure on the two sides causes the film to vibrate so that there is danger of the gelatin coating touching the nozzles which would

* Research Laboratory, Eastman Kodak Company.

produce scratches. The roller R_4 consists of two narrow soft rubber discs bearing on the perforations and held down by a light tension spring. This prevents the film jumping off the roller or backing down when threading the machine. It is convenient to turn on the air pressure by means of a trigger, otherwise the air flow interferes with the threading.

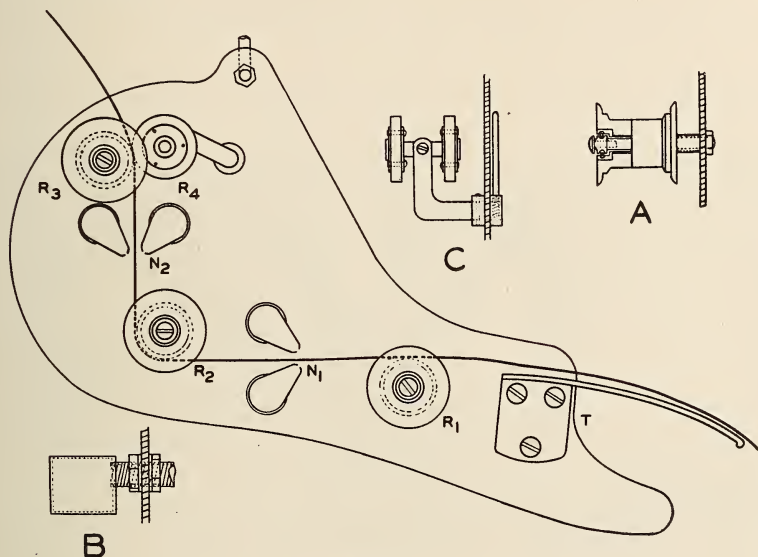


FIG. 1

Rollers R_1 , R_2 , and R_3 are shown in section at A, Fig. 1. The emulsion side of the film is in contact with rollers R_2 , and R_4 but only over the perforation area. A section of the nozzles N_1 and N_2 is shown at B and of the roller R_4 at C. A photographic elevation of the squeegee is shown in Figs. 2 and 3.

The rollers and air nozzles are assembled on an aluminum plate in the relative positions shown in Fig. 1 which is drawn to scale.

The Air Nozzles

Careful adjustment of the air nozzles is necessary to insure efficient removal of the water. An angle of inclination of about 40° to the film was found satisfactory with a $1/32$ inch slit, an air pressure of 20–30 pounds per square inch, and a separation of $1/8$ inch between the nozzles and the film.

Air is supplied to the nozzles by means of a four way junction from a main supply distributed through pressure rubber tubing, Fig. 3. A pressure regulator should be inserted in the air line so as to insure uniform performance of the squeegee.

Manipulation of Squeegee

Although it is possible to hold the squeegee before the drying reel if two persons are employed for the film transfer, it was found preferable to suspend the apparatus from a pulley traveling along a wire cable stretched in front of the drying reels as shown in Fig. 4,

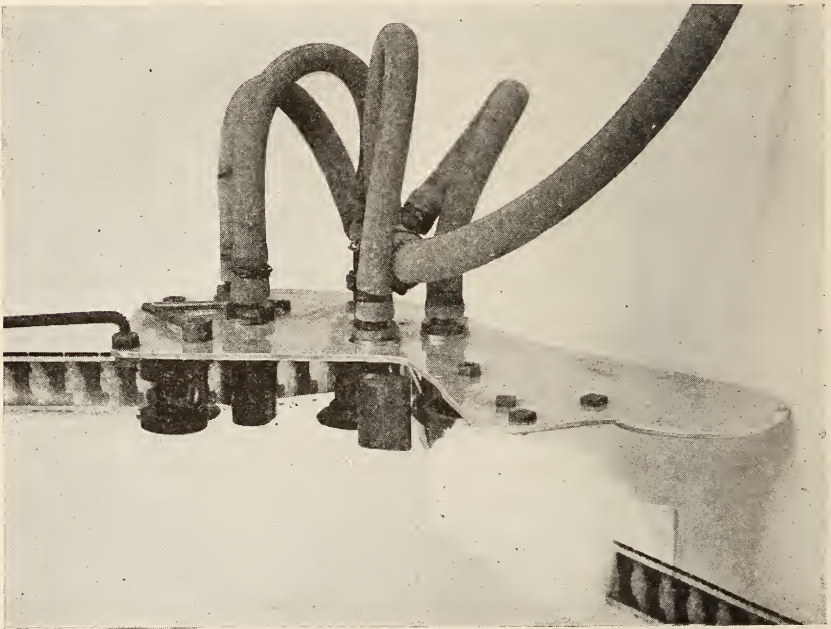


FIG. 2

which clearly indicates the method of use. It is necessary to maintain a free loop of film between the rack and the squeegee and to maintain a constant speed of rotation of the drying reel during loading, which must be slower than during drying. With two persons employed for loading the reel speed can be regulated by hand, but with one operator it is necessary to control the speed of the reel by means of a foot brake. The precise braking mechanism required depends on the nature of the reel drive. Usually a band brake fitting over a drum attached to the

reel axle and actuated by a foot lever will suffice. The operator must unwind the film rack, progress the squeegee along the drying reel, and control the drying reel speed simultaneously, but this can be accomplished with a little practice.

Rate of Drying of the Film

With the above mentioned air pressure and nozzle adjustment, the water is thoroughly removed with the film passing through the

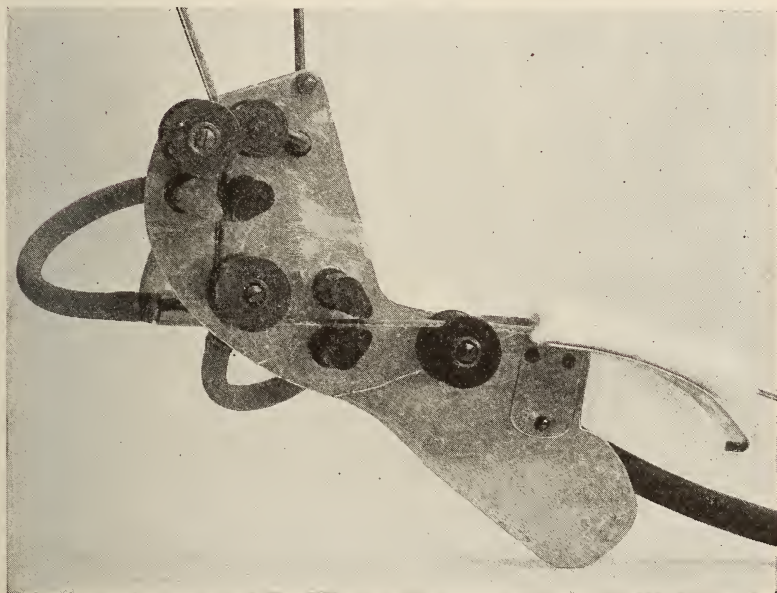


FIG. 3

machine at a speed of 2 feet per second. When running at higher speeds it is necessary to increase the air pressure, but this increases the propensity of the film to vibrate rapidly between the nozzles, thus increasing the possibility of scratching. About 2 minutes are therefore required to transfer 200 feet of film to the drying reel. While this is somewhat longer than is required for this operation without the use of an air squeegee, no later wiping is required, while the drying time is shortened because drying is well under way when the film reaches the drying reel. With ordinary methods drying is retarded where the film passes over the reel slats because the latter were wetted during transference of the wet film from the rack.

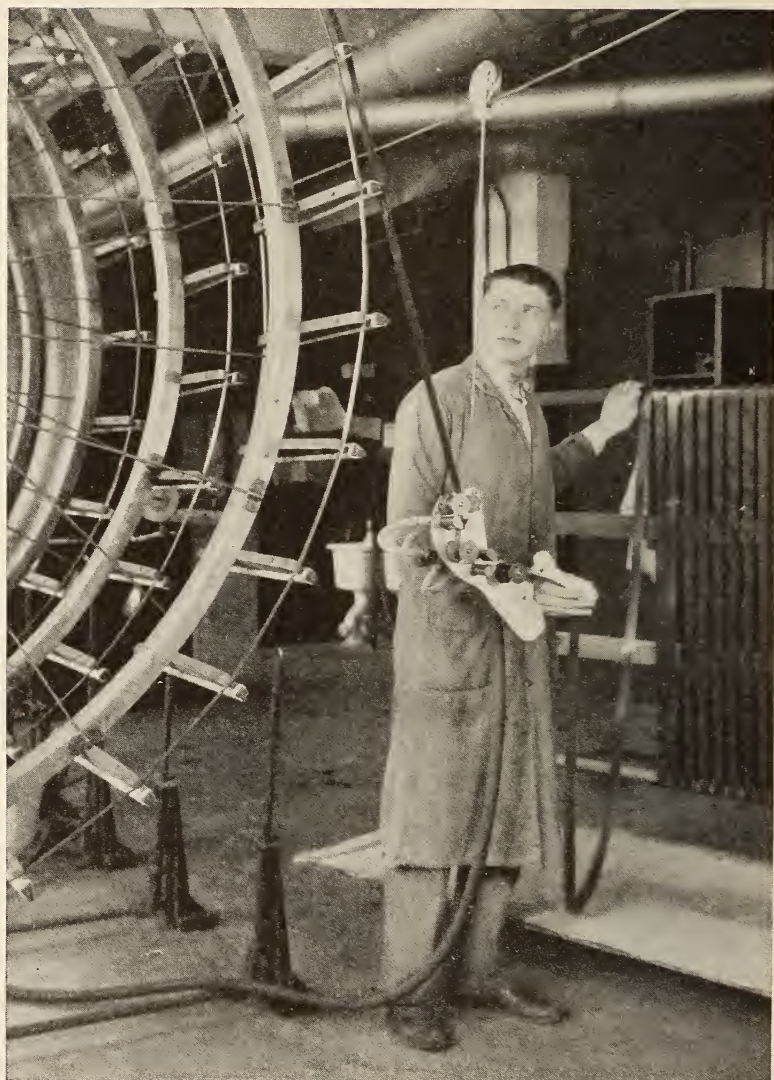


FIG. 4

Measurements of the drying times for motion picture positive film at a temperature of 75°F and relative humidity 70 per cent with cotton wiping and air squeegeeing were as follows:

	<i>Cotton Wiping</i>	<i>Air Squeegeeing</i>
Time for loading reel	2 min.	3 min.
Time for wiping film	2 "	nil.
Time for drying	19 "	16 min.
Time for polishing film	2 "	nil.

Thus, a 25 per cent saving of time is effected by the use of the air squeegee, while subsequent polishing of the film is unnecessary.

The Air Supply

Air from a mechanical blower usually contains fine particles of oil in suspension. It is very necessary that the air supply should be

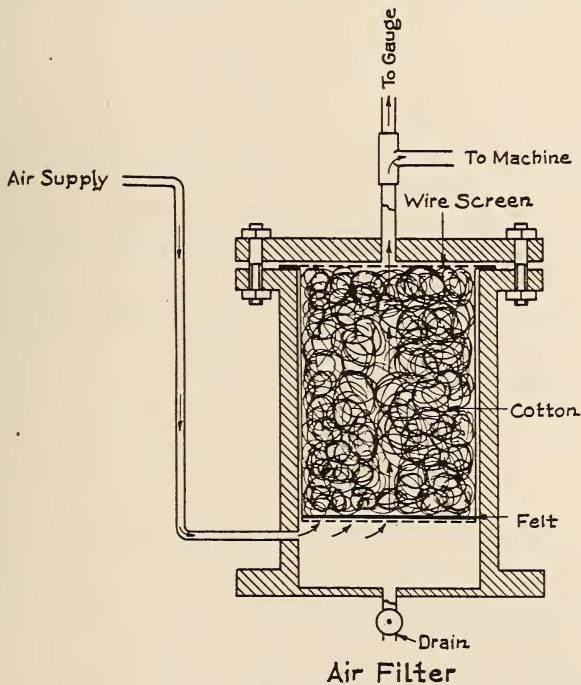


FIG. 5

entirely free from oil, otherwise drops of oil on the film prevent the emulsion from drying and cause crater-like markings on the surface which may be ferrotyped due to contact with the film base when wound in the roll. They may be prevented by filtering the air supply thoroughly. A satisfactory filter for this purpose is shown in Fig. 5. This consists of a metal cylinder about 18 inches long and 9 inches in

diameter fitted with a coarse brass wire screen top and bottom and packed with absorbent cotton. This fits inside an outer casing the details of which are clearly illustrated. The cotton should be renewed at frequent intervals and the filtered air supply tested before commencing work by placing a moistened cloth over the air nozzles for 1 minute. Any discoloration of the cloth indicates that the air has not been efficiently filtered.

In some cases two or more filters arranged in series may be necessary to completely free the air from oil.

¹ Trans. Soc. M. P. Eng. 17, 29, 1923; also Brit. J. Phot. 1924 71, 6, et. seq.

² Trans. Soc. M. P. Eng. 16, 163, 1923; also Le Phot. 1924 11, 89, et. seq.

Copies of previous issues of the TRANSACTIONS that are still available may be obtained on application to the secretary, Mr. L. C. Porter, Fifth and Sussex Streets, Harrison, New Jersey.

Nos. 1, 6, and 9 are out of print. The prices of the others are as follows:

Nos. 2 to 8, \$0.25 each; Nos. 10 to 15, \$1.00 each; Nos. 16, 17, 18, \$2.00 each; Nos. 19 to 28, \$1.25 each.

The supply of some issues is limited.

The Board of Governors decided that a file of the TRANSACTIONS should be bound and placed in the custody of the Secretary. Another bound file was to be placed in the library of the Engineering Society. It was found, however, that no copies of Nos. 1, 6 and 9 were among the back numbers in the possession of the Society, and an appeal was made at the Spring meeting for copies of the same. Two copies of Nos. 6 and 9 have since been presented to the Society and it is earnestly hoped that two copies of No. 1 may also be obtained. Should any member have surplus copies, or does not place great value on his copy of this issue, the Society will gratefully receive the same.

CLEANING LIQUIDS FOR MOTION PICTURE FILM

J. I. CRABTREE AND H. C. CARLTON*

IT IS necessary to clean motion picture film at various stages in its progress from the laboratory to the theatre to remove:

1. Dirt on the base side of negative or positive film;
2. Dirt or grease which may accumulate on negative film during printing;
3. Dirt and oil which accumulates on positive film during projection.

1. When processing in the laboratory by the reel and tank system, if all excess water is not removed from the film previous to drying, any dissolved salts present in the water supply remain on the film after evaporation of the water. The residual salts are usually only visible on the base side of the film because on the emulsion side they have an opportunity to diffuse within the gelatin coating during drying.

It is necessary to clean the back of the dried film either by wiping with a damp chamois while on the drying reels or by passing the film through a cleaning machine. Such treatment is unnecessary in the case of positive film if all excess water is removed previous to placing on the drying reel by thorough wiping or squeegeeing.

In the case of negative film it is customary to wind it with the emulsion side downward onto a wooden drum covered with cloth when the base side may be cleaned without danger of injuring the image. The cloth should be removed from the drum at frequent intervals for cleaning.

A suitable cleaning liquid for the above purpose should possess the following properties:

(a) It should be capable of dissolving traces of inorganic salts and should also dissolve or emulsify grease and mineral oil;

(b) It should be sufficiently volatile and should not cause the gelatin side of the film to swell in a period of several seconds if it accidentally has access to it;

(c) The liquid should not affect the physical properties of film with safety or nitrate base or remove the color from film with tinted base.

A suitable mixture fulfilling the above conditions is the following:

* Research Laboratory, Eastman Kodak Company.

	<i>Metric</i>	<i>Avoir.</i>
Ammonia (conc.)	5 cc.	2/3 oz.
Water	95 cc.	12 oz.
Denatured alcohol (see below) to make	1000 cc.	1 gallon

The ammonia serves to emulsify any traces of grease or oil, while the mixture contains sufficient alcohol to prevent dangerous swelling of the gelatin if any of the mixture reaches the emulsion side of the film.

A choice of several alcohols for preparing the above liquid is available as follows:

Grain alcohol (ethyl alcohol). This is the most satisfactory for the purpose since it has a minimum effect on the film base.

Denatured alcohol. Ethyl alcohol is available containing a variety of denaturants. The most common denaturant is wood alcohol which dissolves nitrate film base so that this should be avoided if possible.

The most commonly available denatured alcohol is motor alcohol. The "Pyro" brand of the Industrial Alcohol Company is prepared according to the following formula No. 5 of the U. S. Internal Revenue Bureau:

Ethyl alcohol	100	volumes
Wood alcohol	2	volumes
Pyridin bases	0.25	volumes
Kerosene	0.5	volumes

On diluting this with water the alcohol turns milky owing to the kerosene coming out of solution. Kerosene has no effect on the film base or gelatin coating and serves to dissolve grease. Although pyridin and wood alcohol attack the film base when pure, in the above concentration and when diluted with water in the above formula they have no harmful effect on the film base during the time required for cleaning. The above cleaning liquid prepared with "Pyro" motor alcohol had only a slight tendency to produce curl on film with nitrate or acetate base after complete immersion for 24 hours at 70°F.

Isopropyl alcohol. This is now available commercially and the "practical" grade is satisfactory for the purpose. It does not turn milky on mixing with water and has little or no curling effect on film with either nitrate or acetate base even on immersion for several hours. It is non-poisonous,¹ is not decomposed on exposure to light and when used in the above mixture does not attack the silver image or the gelatin coating.

Tertiary butyl alcohol is also available commercially and has properties similar to those of isopropyl alcohol. Its odor, however, is somewhat objectionable.

All the above alcohols tend to remove more or less of the tint from nitrate or safety tinted base film but the water present in the above cleaning liquid greatly retards this action.

The precise effect of cleaners prepared with the various alcohols on the tinted base is shown in the following table. Samples of film were immersed in the cleaners and the times required for visible signs of removal of the color were observed.

Effect of Film Cleaning Liquids on Tinted Base Film

<i>Formula</i>		<i>Safety Base</i>	<i>Nitrate Base</i>
Ammonia (conc.)	5 cc.	Liquid slightly	Same as safety
Water	95 cc.	colored in 10	base
Motor alcohol to	1000 cc.	minutes	
Ammonia (conc.)	5 cc.	No effect in 2	Liquid slightly
Water	95 cc.	hours	colored in 10
Isopropyl alcohol to	1000 cc.		minutes
Ammonia (conc.)	5 cc.	Slight effect in	No effect in 16
Water	95 cc.	1 hour	hours
Tertiary butyl alcohol to	1000 cc.		

The propensity of the cleaner to remove the tint varied with different colored bases but the above table gives data for the base which was most readily attacked. Since the period of application of the cleaning liquid is very much shorter than that required to visibly affect the tinted base, the cleaners are considered satisfactory.

2. When making positive prints from negative film, the negative accumulates more or less dirt, grease, and loose particles of dust which must be removed at frequent intervals. In any case it is advisable to remove dust after every third or fourth passage through the printer by passing through silk plush (cut on the bias) moistened with a suitable cleaning liquid as the film is being wound on a re-winder. More thorough cleaning of the emulsion side can be effected by winding the film base side downward on a cloth-covered drum as above.

The requirements of a suitable cleaning liquid for this purpose are similar to those for positive film dealt with below.

3. Positive film accumulates more or less dirt and oil during its passage through the projector which causes spots and patchiness on

the screen. In this connection film which has been toned has a greater tendency to show oil spots than untoned film, which is presumably a result of the matte surface produced by certain toning processes. The oil and dirt may be effectively removed from the film by immersing in a suitable oil solvent, with or without scrubbing, and then removing the excess solvent by squeegeeing and buffing. A satisfactory machine for this purpose has been described by Faulkner.² A less satisfactory method of applying the solvent is by means of silk plush as the film is being wound on a rewinder.

Various liquids have been suggested for the above purpose but the precise effect of such liquids on the film base and on the image, so far as is known to the authors, has not been investigated. Moreover, in certain cases deterioration of the film image has been definitely traced to the use of unsuitable chemicals. An investigation to determine the most suitable liquids for the above purpose therefore seemed desirable.

Requirements of a Suitable Film Cleaning Liquid

A suitable film cleaning liquid should possess the following properties:

1. It should readily dissolve fats and mineral oils;
2. It should not affect the gelatin coating or the film base, or remove the color from film with tinted base. Also it should not attack the silver image or a tinted or toned image even on prolonged contact in the presence of moisture, because when cleaning on a rewinder any excess of solvent which does not evaporate is trapped between the convolutions of the film, when it can evaporate only very slowly;

It should also not decompose on exposure to light to give products which are injurious to the film;

3. The boiling point and latent heat of vaporization should be such as to permit of sufficiently rapid drying;

4. It should be non-combustible, non-toxic, and be readily available at a reasonable price.

At the outset a survey was made of all the possible commercially available non-inflammable and inflammable oil solvents, and the most promising of these were investigated as follows.

Non-Inflammable Oil Solvents

The following compounds were selected by virtue of their suitable volatility, solvent action, and price:

<i>Solvent</i>	<i>Formula</i>	<i>Boiling Point</i>
Dichlorethylene	$C_2H_2Cl_2$	56–60°C
Trichlorethylene	C_2HCl_3	85–87°C
Tetrachlorethylene	C_2Cl_4	119–121°C
Ethylene dichloride	$C_2H_4Cl_2$	83°C
Carbon tetrachloride	CCl_4	76°C

The effect of these compounds on the film was investigated as follows:

Effect of Non-Inflammable Solvents on Motion Picture Film

The effect of the above solvents on film was studied by placing a strip of developed positive motion picture film (nitrate base) in a 100 cc. stoppered bottle with 40 cc. of the solvent and 3 cc. of water at room temperature. The film was thereby subjected both to the liquid and its vapors. Any tendency of the film to curl or of the image to change color was observed after 18 hours with the following results:

<i>Solvent</i>	<i>Condition of Film (nitrate base) after 18 hours at 70°F.</i>
Dichlorethylene (pure E.K.Co.)	Slight curl when wet. Bad curl when dry. No effect on image.
Trichlorethylene (Com.E.K.Co.)	No effect on film base. Emulsion softened and image obliterated.
Trichlorethylene (pure E.K.Co.)	No effect on image or film base.
Tetrachlorethylene (Dow)	Slight curl when dry. No effect on image.
Ethylene dichloride (pure E.K. Co.)	Bad curl. No effect on image.
Carbon tetrachloride (Dow)	No effect on base or emulsion.
Carbon tetrachloride (pure E.K.)	No effect on base or emulsion.

Any curling tendency in the above tests was an indication that the film base had been attacked. The tests show that dichlorethylene and ethylene dichloride exert a solvent action on the base, while commercial trichlorethylene affects the gelatin coating and the image; these liquids are therefore unsuitable. Further tests were made with pure trichlorethylene, tetrachlorethylene, and carbon tetrachloride at 95°F. as follows:

Effect of Non-Inflammable Solvents on Motion Picture Film at 95° F.

<i>Solvent</i>	<i>Condition of Film (nitrate base)</i>
Trichlorethylene (Roessler & Hasslacher)	No effect on base. Image turned slightly brown in four days.
Tetrachlorethylene (Dow)	Image attacked at surface of liquid at end of four days.
Carbon tetrachloride (Dow)	Started to curl at end of six days. No effect on image.
Carbon tetrachloride (pure E.K. Co.)	Started to curl at end of eight days. No effect on image.
Carbon tetrachloride (taken from fire extinguisher)	Film curled at once and turned brown above liquid at end of three days.

Any effect of the above solvents on the image was attributed to decomposition in the presence of water with the liberation of hydrochloric acid. A sample of old tetrachlorethylene which was strongly acid was treated with anhydrous sodium carbonate which would remove any acid present, and this sample had no effect on the image. Another acid sample was treated with anhydrous calcium chloride to remove water but this affected the image showing that hydrogen chloride when dissolved in the solvent and in the absence of water will attack the image. To confirm this, dry hydrogen chloride was passed into pure dry carbon tetrachloride. The resulting liquid attacked the silver image bleaching it to white silver chloride.

The above tests indicated that of the solvents tested, carbon tetrachloride is the most resistant to decomposition by heat and moisture.

Effect of Light on Solvents.

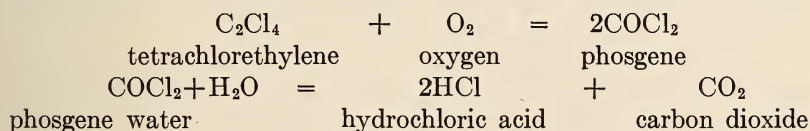
Since on storage, solvents are subjected to the action of light, the effect of exposure to light on the rate of decomposition was studied. In order to secure an accelerated effect, the solvents were exposed in open bottles in the presence of moisture to a quartz mercury vapor lamp for from 5 to 30 hours. Strips of film were then immersed in the light exposed solvents for varying times and any effect on the base or silver image was observed.

The acidity of the samples was also determined by adding an equal volume of water, shaking thoroughly, and titrating with dilute normal caustic soda. As shown by the following table, the effect on the film image was roughly proportional to the quantity of hydrochloric acid present.

Effect of Light on Solvents at 70°F.

Nature of Solvent	Time of Exposure to		Remarks
	Vapor Lamp	Acidity Mercury (cc. N/10 NaOH)	
Trichlorethylene (Roessler & Hasslacher)	None	0.12 cc.	Slight curl. No effect on image in 10 days.
Trichlorethylene (R. & H.)	5 hours	1.10 cc.	Film badly curled. Image bleached in 2 days.
Tetrachlorethylene (R. & H.)	None	0.12 cc.	No effect on film in 10 days.
Tetrachlorethylene (R. & H.)	5 hours	0.65 cc.	Image destroyed in 2 days.
Carbon tetrachloride (R. & H.)	None	0.09 cc.	No effect in 10 days.
Carbon tetrachloride (R. & H.)	31 hours	0.09 cc.	Image turned brown in 10 days.

The above results show that trichlorethylene and tetrachlorethylene under the influence of violet light and moisture undergo decomposition. The compounds are probably oxidized to phosgene (COCl_2) which is decomposed by moisture to form hydrochloric acid and carbon dioxide as represented by the following equations.



The hydrochloric acid formed attacks the gelatin causing it to soften, and likewise converts the image to silver chloride. The extreme toxicity attributed to old or impure samples of compounds of this type is undoubtedly due to the presence of phosgene.

Of the non-inflammable compounds tested, carbon tetrachloride most nearly approaches the ideal film cleaning liquid as outlined under the above list of requirements. It is especially valuable since when pure it does not readily decompose under the influence of light to form compounds which are injurious to the film. However, in order to prevent any possible decomposition on storage, it should be kept in brown bottles or opaque containers.

Inflammable Film Cleaning Liquids.

In addition to non-inflammable solvents, a survey of possible inflammable liquids was also made because it was considered that in the event that an otherwise suitable liquid in this classification was discovered, its objectionable inflammability might be partly overcome by admixture with carbon tetrachloride.

The only promising solvents under this classification were benzene, toluene, xylene, gasoline and allied petroleum distillation products. Tests with these compounds, similar to those made with the non-inflammable compounds above, showed that none of the solvents affected the silver image, but benzene and toluene caused film with nitrate and acetate base to curl after immersion for 2 days at 70°F. All these solvents evaporate more slowly than carbon tetrachloride which in some cases may be desirable.

It was considered that possibly these compounds might be considerably less toxic than carbon tetrachloride, in which case it would be desirable to use them with the addition of only sufficient of the tetrachloride to remove danger of explosion.

Toxicity of Benzene, Gasoline, and Carbon Tetrachloride.

Although no practical toxicity tests were made with the solvents under investigation, adequate information is to be found in the literature. Tests with animals have shown that benzene, gasoline, and halogen substitution products of the hydrocarbons such as carbon tetrachloride all produce varying stages of poisoning resulting in dizziness and unconsciousness, and finally death.

Lehmann³ found that with cats, air containing 20 to 30 mg. per liter of benzene causes loss of consciousness in a few hours and 42 mg. per liter produced death. Hamilton⁴ quotes a large number of cases of benzene poisoning in industry, some of which resulted in death.

Haggard⁵ experimented with dogs and found that the toxicity of gasoline was about one-half that of benzene.

Lehmann,⁶ working with rabbits, found that 240 mg. per liter of carbon tetrachloride were necessary to produce death in two hours. Although no data were found giving a direct comparison between the toxicity of carbon tetrachloride, benzene, and gasoline, a survey of the experiments of Haggard and Lehmann indicates that carbon tetrachloride is less toxic than benzene and slightly more toxic than gasoline though this depends on its purity. Few cases of industrial

poisoning by carbon tetrachloride have been recorded and these deaths were probably due to the use of an impure product which may have contained an excess of phosgene and hydrogen chloride. Since the presence of 3 to 5 mg. per liter of carbon tetrachloride imparts a strong odor to the air, there is no excuse in practice for the concentration approaching the danger point, which is 10 times this concentration.

*The Suitability of Carbon Tetrachloride for Cleaning
Motion Picture Film.*

The above experiments indicate that carbon tetrachloride when pure is quite satisfactory for cleaning motion picture film. It is a good solvent for oils and fats, evaporates readily, is non-combustible, and is readily available at a reasonable price. It does not affect the image even on prolonged contact and has a minimum tendency to decompose on exposure to light in the presence of moisture. Although toxic when impure, the pure compound is no more toxic than benzene and if reasonable ventilation is provided, it may be used with relative safety.

Tests also showed that carbon tetrachloride has no curling effect on film with nitrate or safety base after two days and it does not remove the color from either nitrate or safety film with tinted base.

Manufacturers such as the Dow Chemical Co. and the Eastman Kodak Company supply sulphur-free carbon tetrachloride which is satisfactory for cleaning film. A few years ago many commercial samples of tetrachloride contained sulphur chloride which was formed as a by-product in its manufacture by the action of chlorine on carbon disulphide. On exposure to the air in the presence of moisture sulphur chloride deposits sulphur which is capable of combining with the silver image to form yellow silver sulphide. Such samples of carbon tetrachloride containing sulphur chloride when left in contact with motion picture film attacked the image, especially in the presence of moisture, and bleached it out to a faint yellowish-white image of silver sulphide. No such commercially impure samples of carbon tetrachloride have been encountered within the past two years.

Mixtures of Carbon Tetrachloride with Inflammable Solvents.

In some laboratories and exchanges a mixture of carbon tetrachloride with high test gasoline is used for film cleaning. This mixture evaporates less readily than pure tetrachloride which may be an advantage in some cases. Its adoption in the past was a result of the

toxicity of impure samples of tetrachloride, a 50% mixture by volume with gasoline reducing this considerably. This mixture burns with great difficulty and is satisfactory from a fire hazard standpoint although the proportion of the two liquids necessary to give a non-inflammable mixture depends on the nature of the gasoline. It is considered that pure carbon tetrachloride is to be preferred to such a mixture for general purposes.

Film Moistening Liquids.

In addition to accumulating oil during projection, both the film base and gelatin coating lose moisture and tend to become brittle owing to the excessive heat to which the film is subjected. If the film were allowed to cool to room temperature between successive projections, little trouble would be encountered, but in practice the film does not cool off sufficiently between successive projections and the resulting baking process drives out the moisture, which results in brittleness.

If film which has been rendered brittle in this manner is exposed to a moist atmosphere even for only a relatively short time it tends to regain its flexibility. It is not possible to do this by placing the tightly wound reels of film in a humidior or a vessel containing water because the moisture penetrates the convolutions of film very slowly. It would be possible to humidify the film satisfactorily by passing it continuously through a humid chamber or by winding the film in contact with a damp strip of paper or other absorbent ribbon. Such a system however, is inconvenient in the theatre or exchange.

A satisfactory method of moistening film is to immerse it in a mixture of water and a water-miscible volatile liquid such as grain alcohol. The percentage of water to be used in the mixture depends on the degree of brittleness of the film and the time which elapses between application and evaporation of the liquid. If an application machine of the Dworsky² type is used, this depends on the rate of passage of the film through the machine. During this short period little or no swelling of the gelatin coating occurs, but sufficient moisture is absorbed to restore the flexibility of the dried out gelatin coating. Moreover, when the film is wound up in a roll, the dried out film base can also absorb moisture by virtue of being in contact with the moistened emulsion. Film base absorbs moisture relatively slowly so that little or none is absorbed by it in the period of application of the moistening liquid.

At the outset a survey was made of possible water-miscible volatile liquids which could be used for the purpose. The requirements of such a liquid are identical with those for the film base cleaning liquid already outlined. A choice of the following liquids is possible; grain alcohol, denatured alcohol, isopropyl alcohol, and tertiary butyl alcohol.

The exact quantity of water to be added to the alcohol must be determined by trial. From 15 to 25 per cent water is usually satisfactory and this proportion holds in the case of all the alcohols named above. The condition of the film after treatment will indicate any necessary changes in the proportion of water to be added. If it is too tacky less water should be used and if too dry and brittle the quantity should be increased.

A mixture of either of the above alcohols with water has little or no solvent action on mineral oil which may be present on film after projection. However, in practice the rubber squeegees in the Dworsky¹ machine tend to emulsify and remove traces of oil. If much oil and dirt is present on the film a moistening liquid which is also capable of dissolving oil must be used.

Combined Cleaning and Moistening Liquids

It is possible to incorporate a mineral oil solvent such as carbon tetrachloride with any of the above alcohol-water mixtures. The quantity of carbon tetrachloride which can be added depends on the quantity of water present in the alcohol. For example: tertiary butyl alcohol and carbon tetrachloride, and water and tertiary butyl alcohol are miscible in all proportions. Water and tetrachloride are immiscible, but if water is gradually added to a mixture of the alcohol and carbon tetrachloride with shaking, a uniform mixture is obtained until a critical quantity of water has been added, beyond which the mixture turns milky and the liquid separates on standing into two phases or separate layers. The quantity of water which a given mixture of the alcohol and carbon tetrachloride will hold depends on the alcohol content and on the temperature, the mixture holding less water at lower temperatures.

A curve showing the limiting quantity of water which can be added to mixtures of tertiary butyl alcohol and carbon tetrachloride in varying proportions is given in Fig. 1. Commercial samples of the alcohol are apt to contain varying quantities of water. The data are for a practical grade of tertiary butyl alcohol which was practically anhydrous.

The miscibility curves for grain alcohol, denatured alcohol, isopropyl alcohol, and tertiary butyl alcohol are approximately identical for all practical purposes. For the preliminary experiments the following formula was used as a cleaner:

Water	15 parts by volume
Carbon tetrachloride	20 " " "
Alcohol to make	100 " " "

Of the cleaning liquids prepared according to the above formula the one containing denatured or grain alcohol had little or no solvent

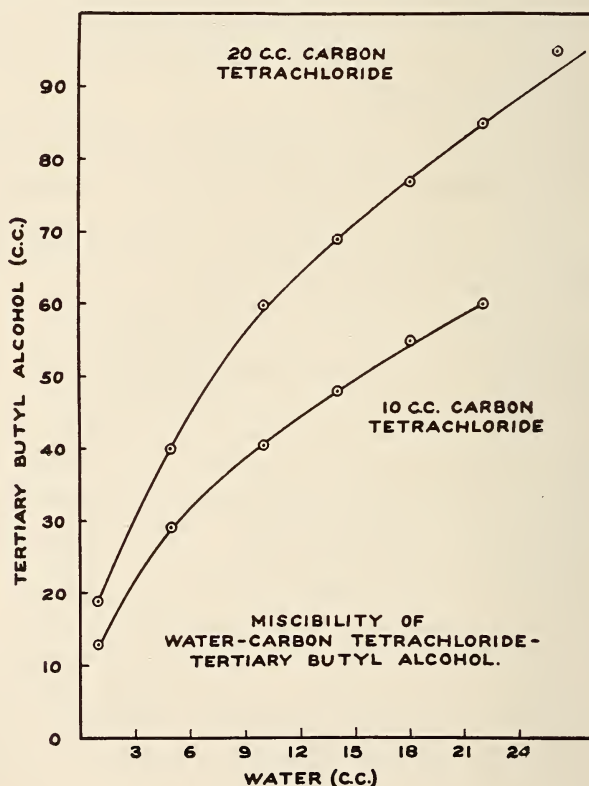


FIG. 1

properties for mineral oil so that it had no advantages over a plain alcohol-water mixture. When prepared with isopropyl alcohol the mixture dissolved 1 per cent of light machine oil and with tertiary butyl alcohol about 3 per cent of oil. Since the quantity of oil on

dirty film is never such that the concentration of oil in the cleaning fluid would exceed this, the isopropyl and tertiary butyl mixtures were considered promising.

In order to determine the effect of the above mixtures on the film, strips of safety and nitrate motion picture film with plain and tinted bases were immersed in glass bottles containing the various liquids and stored for several days at 70°F. The results obtained were as follows:

*Effect of Cleaning and Moistening Liquids
on Motion Picture Film at 70°F.*

<i>Formula</i>	<i>Effect on Film Base</i>	<i>Effect on Gela- tin Coating and Image</i>	<i>Effect on Tinted Base</i>
Water 15 cc.	<i>Acetate</i>	Changed silver image to white silver chloride in 20 hours	Slight solvent action in 5 min.
CCl ₄ 20 cc.	Slight curl		
Isopropyl alcohol to 100 cc.	<i>Nitrate</i> Slight curl in 20 hours		
Water 20 cc.	<i>Acetate</i>	No effect on image	<i>Acetate</i> Slight solvent action in 20 min.
CCl ₄ 10 cc.	Slight curl in 20 hours		
Ter. butyl alcohol to 100 cc.	<i>Nitrate</i> No effect in 20 hours		<i>Nitrate</i> No effect in 60 min.

In the case of the isopropyl alcohol mixture an interaction between the alcohol or possibly an oxidation product of this and the tetrachloride occurred causing the liberation of hydrogen chloride which attacked the silver image, converting it to silver chloride. Although neither isopropyl alcohol nor carbon tetrachloride when used alone attacked the silver image, on mixing the two in the presence of water and adding a little silver nitrate solution, a white precipitate of silver chloride formed within a period of a few minutes. No such action occurred with tertiary butyl alcohol.

The interaction of the alcohols with carbon tetrachloride in the presence of water was investigated further by exposing mixtures prepared with the different alcohols to ultra-violet light. In the case of mixtures of tetrachloride and water with denatured alcohol

and isopropyl alcohol, the image was attacked in 8 hours. No effect was obtained with a mixture containing tertiary butyl alcohol after exposure for 24 hours.

Of the combined cleaning and moistening liquids tested, the following was the most satisfactory:

Carbon tetrachloride	10 parts by volume
Water	20 " " "
Tertiary butyl alcohol to	100 " " "

This has no harmful effect on the film, it dissolves a sufficient quantity of mineral oil and it humidifies the gelatin coating. If it is necessary to increase the quantity of water in the formula, the proportion of the ingredients to give a clear solution is indicated by the miscibility curve in Fig. 1.

The capacity of the unused liquid for dissolving mineral oil is limited, but with use the liquid will dissolve a greater proportion of oil as a result of dehydration of the liquid by virtue of the absorption of water by the gelatin coating of the film. Unless the liquid is used for long periods it is usually not necessary to add a further quantity of water to compensate for that absorbed by the film.

If the film to be cleaned is coated with an excess of oil the above solution may not entirely remove all the oil with one treatment and a second treatment may be necessary.

Experiments have been made with the additions of glycerine and ethylene glycol and mixtures of these to the above solution but the results indicated that these are usually not necessary.

An alternative method of moistening the film is to first remove the oil with carbon tetrachloride and then give the film a second treatment with a mixture of denatured alcohol or tertiary butyl alcohol and water in the proportions outlined above. This involves more labor but is a very satisfactory procedure.

Practical Recommendations.

1. For cleaning the base side of negative and positive film after processing the following solution is recommended:

Ammonia (conc.)	5 parts by volume
Water	95 " " "
Alcohol* to make	1000 " " "

* The "Pyro" brand of denatured alcohol of the Industrial Alcohol Company is satisfactory, although isopropyl alcohol or tertiary butyl alcohol are to be preferred.

The solution may be applied to positive film by means of a cleaning machine and to negative film when wound face down onto a cloth covered drum. Negative film may be cleaned with safety on certain types of sprocketless cleaning machines, but it should not be handled on machines fitted with sprockets owing to the possibility of damage to the film.

2. In order to remove dust and finger markings from negative film it should be cleaned before printing by wiping gently with silk plush moistened with carbon tetrachloride (sulphur-free) as it is being wound on a rewinder. An electric fan should be arranged so as to blow a current of air across the film in a direction away from the face of the operator. The cleaning process should be repeated after every third or fourth print has been made.

3. For cleaning film which has accumulated oil and dirt during projection, carbon tetrachloride (sulphur-free) as supplied by the Dow Chemical Co., is recommended. For cleaning brittle film the following solution at the same time removes oil and moistens the film thus tending to restore its flexibility.

Carbon tetrachloride	10	parts	by	volume
Water	20	"	"	"
Tertiary butyl alcohol to make	100	"	"	"

The quantity of water in this formula should be varied according to conditions. If the film is too moist after treatment less water should be used in the formula and if too brittle more water should be added. In this case it will be necessary to increase the quantity of alcohol also so as to retain the water in solution.

The cleaning liquid may be applied to the film in the same manner as outlined under (2) above. This method is not always satisfactory because if the solvent does not evaporate thoroughly before the film is rewound, more or less solvent is retained between the convolutions of the film and in case an impure solvent is used this will be liable to attack the film image on storage. A film cleaning machine of the type recommended by Faulkner² is to be preferred.

In the case of very brittle film two successive applications may be necessary. The odor of tertiary butyl alcohol may also be objectionable in hot weather.

An alternative procedure is to first remove oil from the film with pure carbon tetrachloride and then moisten the film by passing through a mixture of denatured alcohol, isopropyl alcohol, or tertiary butyl alcohol with 15 to 25 per cent of water.

Although air which contains sufficient carbon tetrachloride to smell perceptibly is not dangerously toxic, ample ventilation should be supplied when using this or any other solvent. In the case of a film cleaning machine, a suitable exhaust hood with carry-off pipes should be arranged over the machine.

Carbon tetrachloride as received in drums often contains a small quantity of water in suspension as fine droplets. Unless the water is removed before use, spots will be left on film after cleaning as a result of local swelling of the gelatin by the water.

The water can be removed readily by pouring the liquid through a vertical glass tube containing granules of anhydrous calcium chloride. A tube 4 or 5 feet long, 3 or 4 inches wide, and fitted with an outlet tube about one-half inch in diameter is satisfactory. A wad of absorbent cotton at the bottom of the tube serves to retain the calcium chloride granules.

To use the column the carbon tetrachloride is poured in at the top and allowed to run out at the bottom directly into the dispensing bottle which has been dried previously. Several gallons can be passed through the apparatus in a few minutes. The calcium chloride should be thrown away and replaced occasionally. Usually several hundred gallons can be treated with the quantity described above. Both ends of the tube should be stoppered when the apparatus is not in use, otherwise the calcium chloride will absorb moisture from the atmosphere.

¹ H. C. Fuller, *Chem. & Met. Eng.* 29, 538, 1923.

² Faulkner, *Trans. S. M. P. E.* 25, 117, 1926.

³ H. B. Lehmann, *Arch. für Hyg.* 75, 1, 1912.

⁴ "Industrial Poisoning in the U. S." by A. Hamilton (Macmillan).

⁵ Haggard, *J. Pharmacol & Exp. Therap.* 16, 401, 1920.

⁶ H. B. Lehmann, *Arch. für Hyg.* 24, 1, 1911.

DISCUSSION

MR. STEWART: When you speak of humidifying brittle film do you wish to imply that any of the moisture goes into the film base?

MR. CRABTREE: Yes.

MR. STEWART: Have you any idea of the moisture content of new film?

MR. CRABTREE: Nitrate film base contains from 1 to 2 per cent of moisture. The gelatin coating when in equilibrium with an atmosphere at 60-70 per cent relative humidity contains from 10-12

per cent of water. Dry gelatin absorbs moisture fairly rapidly when exposed to a damp atmosphere. However, dried out film base absorbs moisture much more slowly and even when totally immersed in water, from 20-30 hours are required for the maximum amount of water to be absorbed.

MR. STEWART: I asked this because some time ago I took a pound of celluloid, soaked it for hours and weighed it again and found no change in weight.

MR. CRABTREE: The fact that the celluloid which you used did not absorb any water proved that it was fairly saturated. In order to make such a test the film should first be baked so as to drive out the moisture and afterwards soaked and weighed again.

MR. STEWART: It was brittle film.

MR. CRABTREE: Possibly the brittleness was due to other causes.

MR. LINDSAY: Does this solution for cleaning and moistening evaporate immediately or would a theater have to have a small drying cabinet?

MR. CRABTREE: The film dries immediately. It first passes through rubber squeegees and is then wiped with buffers. When the film is wound up the base is in contact with the moist gelatin and derives its moisture therefrom. The amount of water absorbed by the gelatin coating is not sufficient to cause sticking.

PROF. WALL: Mr. Crabtree said that the first pneumatic squeegee was used by Mr. Kelley. We fitted one up in Florida in 1917. We had two water sprays to take the grit off the film, then two strips of chamois to take the water off, after which the film passed between the nozzles of the pneumatic squeegee. We had three of these at a distance of about 18 inches and found them extremely efficient.

MR. CRABTREE: That is different. The apparatus which Mr. Kelley used was the first which I know of which was used to dry film during transference by hand from a developing drum to a drying reel. The conventional pneumatic squeegee as used on continuous machines when used for this purpose is apt to damage the film.

SOME TECHNICAL ASPECTS OF THE VITAPHONE

P. M. RAINY*

VITAPHONE is a trade name applied to one method of making and reproducing sound motion pictures. By sound motion pictures we mean the reproduction of scenes in proper timed relation with the reproduction of the natural sounds accompanying the scene or with other sounds designed to produce a desired effect. The sounds may be spoken words, vocal or instrumental music or some form of noise, such as the roar of a passing train, the crash of real or artificial thunder, the squeak of a wheel, the buzz of a bee or a saw, or in fact any air vibration which the ear recognizes. The reproduction of scenes in proper timed relation with the sound naturally involves the recording of both scene and sound in such a way that the proper time relation may be maintained during reproduction.

You gentlemen are familiar with the limitations of recording scenes. You must have certain conditions as regards light intensity, focus, etc., otherwise the recording of the scene will not be faithful in every detail. In the recording of sounds, there are analogous limitations. For example, the sounds to be recorded must be well above the intensity level of extraneous sounds.

The problem of proper time relation between the reproduction of a scene and the natural accompanying sounds is most easily solved by the simultaneous recording of sound and scene. In the case of obtaining the proper time relation between the scene and other than the natural accompanying sounds, as for example, incidental music, the solution is most easily obtained by recording these other sounds in proper time relation with the reproduction of the scene. In either case, precaution must be taken against recording undesirable extraneous noises. For example, the Director's megaphone must be dispensed with during recording and noiseless gestures or signals used to give the desired cues or instructions. The studio must be acoustically suitable with heavily carpeted floors, sound absorbing walls, sound damping draperies, etc., in order to prevent undesirable echoes or reverberations which otherwise would be recorded with detrimental results.

While we are describing a new art, the conception of sound motion pictures is not new. The records of the Patent Offices of the

* Electrical Research Products Division. Western Electric Co.

civilized world bear evidence that the conception of sound motion pictures is more than thirty years old. The advent of the telephone in 1876, the phonograph in 1880, and the motion picture in 1895 appear to have stimulated inventive genius along these lines during the closing years of the past century. It appears also that the practical realization of this vision like the vision of the long distance telephone, radio, transmission of pictures by wire, television, and other developments was long retarded by the lack of fundamental knowledge concerning the underlying principles involved. Imagination has run far ahead of realization.

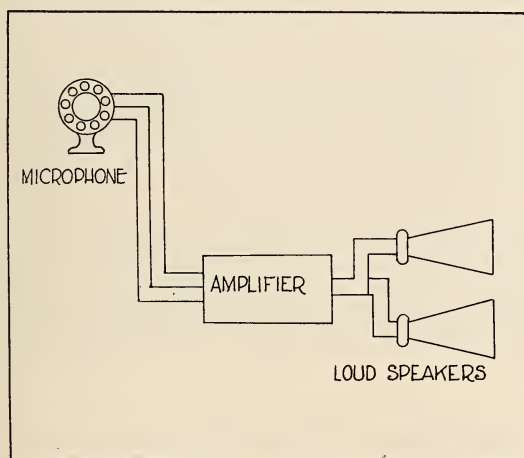


FIG. 1. A public address equipment.

Much has been written about the conquests of the vacuum tube. This magic lamp has converted dreams into realizations in the field of wire and wireless telephony, and is rendering distinguished service in other fields. This powerful new tool, together with the technique which was contemporaneously developed with and around the device, has made this old dream of sound motion pictures a reality. The service rendered by the vacuum tube in connection with sound motion pictures is not spectacular in that it renders a new or unusual service. It simply performs a function which it has been performing in modern telephony, namely, the faithful amplification of sound currents. The apparatus, equipments and methods used, and which we will describe, are with few exceptions, apparatus and methods used

in telephony, and are similar to those used to permit large audiences to hear the words of a speaker present or at a distance. Equipments for this purpose are commonly called Public Address equipments. Fig. 1 is a schematic diagram of a Public Address equipment. The sound waves are picked up by the microphone at the left and converted into electrical sound currents. The currents then pass to the amplifiers where they are amplified sufficiently to operate the loud speakers at the right, and give sufficient volume for the purpose of the particular installation. The loud speakers convert the electrical

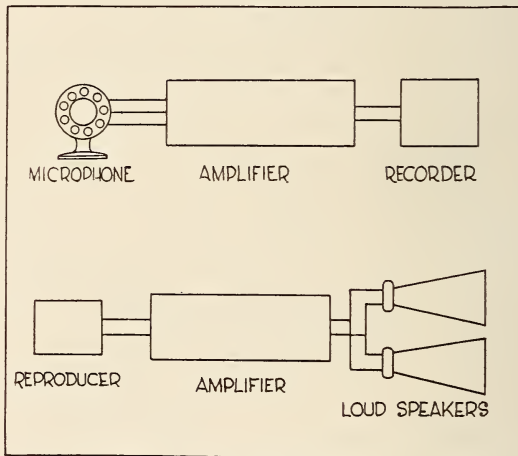


FIG. 2. A schematic diagram of a Vitaphone sound-reproducing equipment.

sound currents into air vibrations or sound. The degree of amplification required may be of interest. The electrical energy developed by the microphone is of the order of 1×10^{-8} watts, the output of the amplifiers which operates the loud speakers may be as much as 40 watts. This means that the amplifiers are giving an energy amplification of four billion.

With this type of equipment there are no acoustic limitations to the size of audience that can be made to hear the voice of a speaker. As a matter of fact the only limitations to the size of a congregation that can be made to hear a speaker are the limitations of transportation and human endurance.

Fig. 2 is a schematic diagram of a Vitaphone sound recording equipment, and a Vitaphone sound reproducing equipment. The similarity between these and Fig. 1 should be noted.

In making sound records the loud speakers of a Public Address equipment are replaced by a recording mechanism in which the amplified sound currents effect recording. In the Vitaphone, these amplified currents are used to actuate a stylus and effect recording in suitable material in the familiar disc form. Experimentally these same currents have been used to vary the intensity of light to which a photographic film is exposed. In either case the result is the same in that a reproducible record is made.

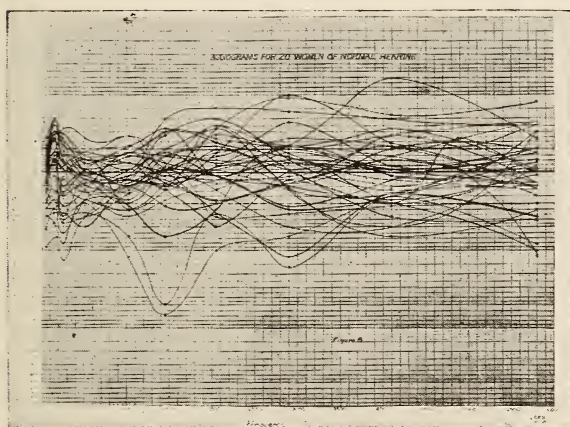


FIG. 3. Sensitivity-frequency curves of the human ear.

In the reproduction from sound records the same type of equipment is used, but instead of replacing the horns by a recorder, the microphone or pick-up equipment is replaced by a suitable reproducer. This reproducer in conjunction with a record generates currents which are amplified and converted into sound by the loud speakers.

Before I describe the apparatus, equipment and methods in detail, permit me to review briefly the fundamental requirements for faithful recording and reproduction of sound.

Sound may be defined as air vibrations to which the ear is sensitive. These vibrations or variations in air density are harmonic or sinusoidal and vary widely in frequency and intensity. The frequencies occurring in ordinary speech, instrumental music and ordinary noises, range from 16 cycles per second to 10,000 cycles per second. Higher frequencies than 10,000 are audible, but are in

general of negligible importance insofar as intelligibility of speech, enjoyability of music or the recognition of familiar sounds is concerned. In this connection it should be borne in mind that the human ear has its limitations, and that the response of the ear to various frequencies is not the same. Further that these variations vary with different individuals.

Fig. 3 shows audiograms or sensitivity frequency curves of twenty women, all possessed of supposedly normal hearing. This slide suggests that there is little wonder that it is difficult to please a large audience of women with any audible rendition.

Most sounds are a combination of a large number of frequencies. In general we are not interested in sounds consisting of a single frequency. Middle "C" on the piano produces a fundamental vibration of 256 cycles per second, but in addition produces overtones of higher frequencies and of varying intensities. The same note on another musical instrument will have the same fundamental frequency, but the overtones will differ either as regards frequency or intensity or both. It is these overtones or timbre, as they are sometimes called, which mark the distinction between the same note on different musical instruments. The character of these overtones determines the quality of musical tone and constitutes the ear-marks by which voices and sounds are recognized. Faithful recording and reproduction must take into consideration the overtones. Faithful sound reproduction, therefore, consists in the regeneration of all of the fundamental and overtone frequencies with the same intensities as they appeared in the original. This means that the microphone, vacuum tubes, transformers, recorders, reproducers and loud speakers should all have a straight line characteristic, i.e., they must not discriminate unduly against any frequency band. They should have the same efficiency at all frequencies within the audible band. This is illustrated by the requirements controlling the design of a transformer for power transmission or for speech or music transmission purposes. The requirements for a good power transformer are in general a high efficiency at one frequency, and at full load. The efficiency at other frequencies, and at times of light load is of secondary importance. In other words, a straight line characteristic is of little importance in comparison with a high efficiency at one frequency and at full load. For the transmission of speech or sound currents, however, we must have a transformer which has approximately the same efficiency over a wide band of frequencies and

variations of load. In fact the uniformity of the efficiency with the frequency and load is more important than whether the efficiency is high or low.

The problem of securing a straight line characteristic throughout the audible range of frequencies is also made more difficult by the fact that the higher frequencies of sound possess much less energy than the lower frequencies. The vessel sounds are low-pitched sounds with great energy, while the consonants are higher-pitched, and possess less energy, hence the suppression of the higher frequencies materially affects the intelligibility of speech, and robs music of its brilliance. The suppression of the lower frequencies robs speech and music of its volume, but has little effect on the intelligibility of speech or the brilliance of music.

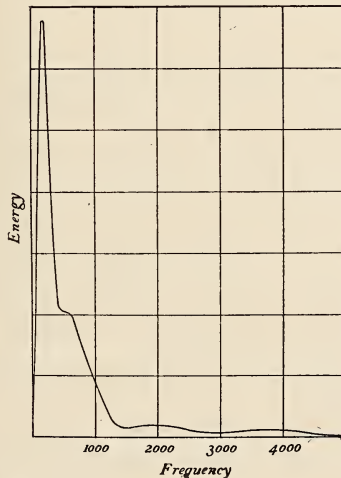


Fig. 4. Energy distribution of speech over the audible frequency range.

Fig. 4 shows the energy distribution of speech over the audible frequency range.

Fig. 5 shows the electrical characteristics of certain electrical circuits known as filters. Three types are shown, high pass, low pass and band pass filters. By low pass filters we mean filters that offer little impedance to low frequency currents and high impedance to high frequency currents. By high pass filters we mean the inverse of low pass filters. By band pass filters we mean a combination of low and high pass filters that suppress all frequencies outside of a certain

band of frequencies. You all remember the story of the eminent scientist that had a carpenter cut a small hole for the small cat after he had finished a large hole for a large cat. Modern electrical filters of the characteristics shown make it appear that this incident may have been prophetic rather than foolish. If we call the big cat a high frequency and the little cat a low frequency, it is plain that the little cat will have as much difficulty in getting through the big hole as the big cat will have getting through the small hole. The band pass filter shown would then represent a medium size hole for a medium size cat.

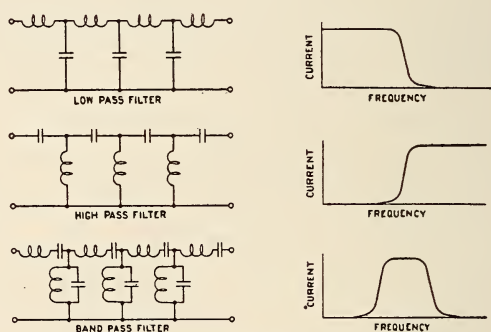


FIG. 5. Characteristics of electrical filters.

Filters of this type make it possible to determine the effect of various frequencies on the intelligibility of speech. They also make it possible to show the effect on musical reproduction when certain frequencies are omitted or partially suppressed. Filters are also used to correct undesirable characteristics.

It would have been cumbersome to have brought all of the apparatus necessary to demonstrate this phenomena, but we have prepared phonograph records which were made with filters which serve the purpose of illustration.

One of these records is a piano selection and the other speech. Each record consists of several repetitions with filters as follows:

1. No filter. Straight line characteristic;
2. A high pass filter suppressing frequencies below 375 cycles per second;
3. High pass filter suppressing frequencies below 750 cycles;
4. No filters;
5. Low pass filter suppressing frequencies above 2,500 cycles;

6. Low pass filters suppressing frequencies above 1,250;
7. No filters.

This clearly demonstrates in the case of speech and music that the volume of sound rests with the low frequencies, and that the low frequencies in speech and music are therefore important. It also demonstrates that the higher frequencies are important in speech from an intelligibility standpoint, and that they provide the brilliance in piano music. High frequencies are, therefore, equally important, and the necessity for a straight line characteristic of both recording and reproducing is therefore established.

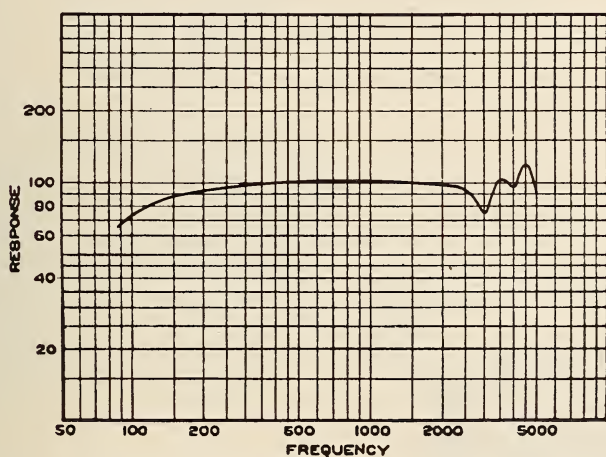


FIG. 6. Frequency characteristic of public address amplifiers.

Fig. 6 shows frequency characteristic of Public Address amplifiers with a carbon button transmitter. While this curve is not a straight line over the entire range, we are pleased to call it a straight line characteristic, particularly since the diversions from the straight line are small in comparison with the variations of the human ear as indicated above.

Fig. 7 shows the characteristics of a Condenser Transmitter with its amplifier plotted to a logarithm scale. It is interesting to note that the characteristics of this microphone are better than shown in the previous diagram, in that they do not discriminate as much against the low or certain high frequencies.

Given means for faithfully recording sound and means for faithful reproduction of sound and means for the faithful recording and

reproduction of scenes, we have only the matter of proper time relation to effect faithful simultaneous reproduction of sound and scene which constitutes sound motion pictures.

In the description which will follow, you will see how simply this has been accomplished in Vitaphone productions. As previously stated where the sounds to be recorded are sounds which naturally

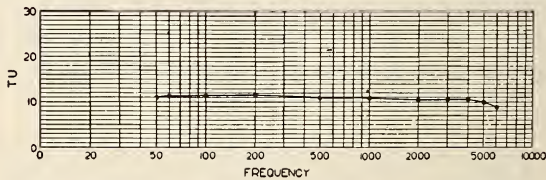


FIG. 7. Characteristics of a condenser transmitter.

accompany the scene, they are preferably recorded in synchronism with the taking of the motion picture. This requires that the sound recording equipment and the camera must be driven at speeds which bear a fixed ratio to each other. Practically this is accomplished by driving both equipments from a single prime mover. In order to provide the necessary flexibility as regards locations of camera and

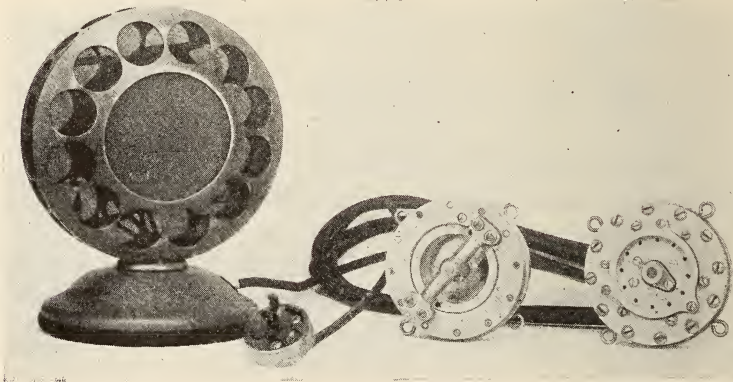


FIG. 8. Carbon button type of transmitter.

recording equipment, and also to permit the use of several cameras, with one sound recording equipment, it has been necessary to develop a synchronous electrical drive which is analogous to mechanical gears or shafting. This method applies if the sound is being recorded either with the taking of a picture or its reproduction.

In reproducing the sound and scene records, it is only necessary that the two records be started at the correct points and run at the same speeds at which the records were respectively taken. In reproduction it is entirely practical to provide mechanical coupling to maintain the proper speed ratio and there is, therefore, no need to use synchronous electrical drive used in connection with recording.

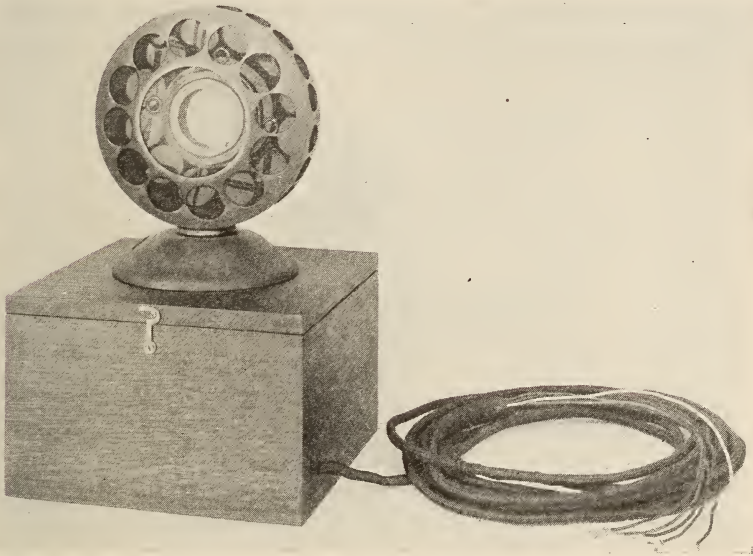


FIG. 9. Electrostatic type of transmitter.

Fig. 8 shows the construction of the familiar carbon button type of transmitter used in Public Address systems and radio broadcasting studios. The transmitter is of the double button, push, pull, air-damped type with a stretched duralumin diaphragm. This instrument is very satisfactory for Public Address and broadcasting work and for certain types of recording work. However, all granular carbon type of transmitters generate certain minute currents, which, when amplified and reproduced by a loud speaker, are known as carbon noises. If these currents are small in comparison with the currents generated by the sound waves picked up by the microphone, they are not objectionable, however, if the sound currents generated by the microphone are of the same order of magnitude as these carbon noise currents, the result is objectionable.

Fig. 9 shows another form of pick-up equipment, a condenser microphone and amplifier. The advantage of this transmitter over the one just described, is that it has no carbon and hence can generate no carbon noise currents; however, its efficiency in converting air vibrations into electrical energy is much lower than the carbon button transmitter just described, and it is necessary therefore to amplify its output to bring it up to the same level as the output of the carbon transmitter. As its name implies, this microphone or transmitter is an electro-static condenser, in which the capacity is

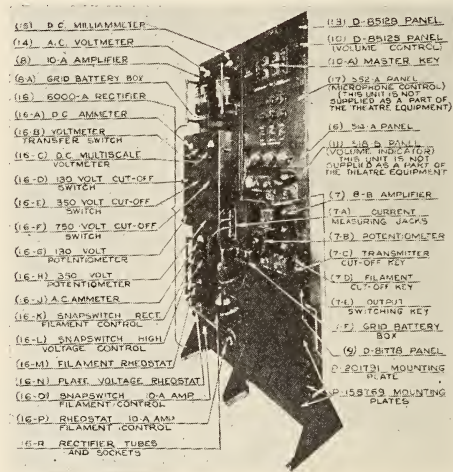


FIG. 10. Wiring diagram of amplifiers of a recording outfit.

varied by the vibration of its stretched diaphragm in response to air vibrations. The capacity of the condenser is so small, that it is necessary to mount its amplifier with exceedingly short electrical connections; otherwise the electrostatic capacity of these connections would still further decrease the already low efficiency. For this reason the microphone is mounted directly on top of the amplifier.

Fig. 10 shows a simplified wiring diagram of the amplifiers of a Public Address system, a recording outfit or a reproducing outfit. If the input is a microphone, and the output feeds into loud speakers, we have a Public Address system. If the loud speakers are replaced by an electrical recorder, we have a recording outfit. If the microphone is replaced by a reproducer, and the amplifier feeds into loud

speakers, we have a reproducing outfit. As previously mentioned, all of the units making up this amplifier are so designed as to maintain the general straight line characteristic which is essential to faithful recording and reproduction. This circuit shows a number of vacuum tubes connected with transformers.

Fig. 11 shows the amplifier of a Vitaphone 1-B theater equipment. In addition to the amplifiers, we have mounted on this framework other panels which are essential to the practical operation of the system. Fortunately, or unfortunately, the arrangement of the apparatus of these panels does not follow the arrangement of the schematic circuit described above. The 8-B amplifier, whose input

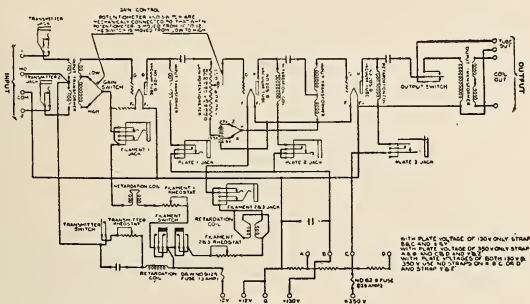


FIG. 11. Amplifier of Vitaphone equipment.

is the output of the Magnetic Reproducer, is mounted at the bottom of the right hand frame-work. This amplifier panel carries a grid battery box, jacks for measuring currents in the filament and plate circuits, a transmitter cut-off key which is used in Public Address work for switching a microphone on or off, and in sound motion pictures is used for cutting off the magnetic reproducer. This panel also carried a potentiometer which makes it possible to vary the amount of amplification, and thus control the volume of the output. The transformers are mounted on the back of the panel. Above the 8-B amplifier is a Volume Indicator panel, which is not now being supplied as a part of the theater equipment. The function of this panel is to give a visual indication of the output of the amplifier as a guide to the operator controlling the volume. Experience to date indicates that this is not absolutely necessary, if the records have been properly recorded. It is standard practice to have an observer located in the audience with a telephone to advise the operator

whether the volume should be raised or lowered in order to produce the most desirable effect for the audience.

Above the Volume Indicator panel is the meter panel. These meters provide means for the operator to observe the current and voltage in various parts of the equipment. Above the meter panel is the microphone control panel which is not required in sound motion picture projection, but is used in connection with microphones for Public Address and recording work. This panel provides means for fading out one microphone and fading in another. At the top of the right hand frame-work is a volume control panel equipped with

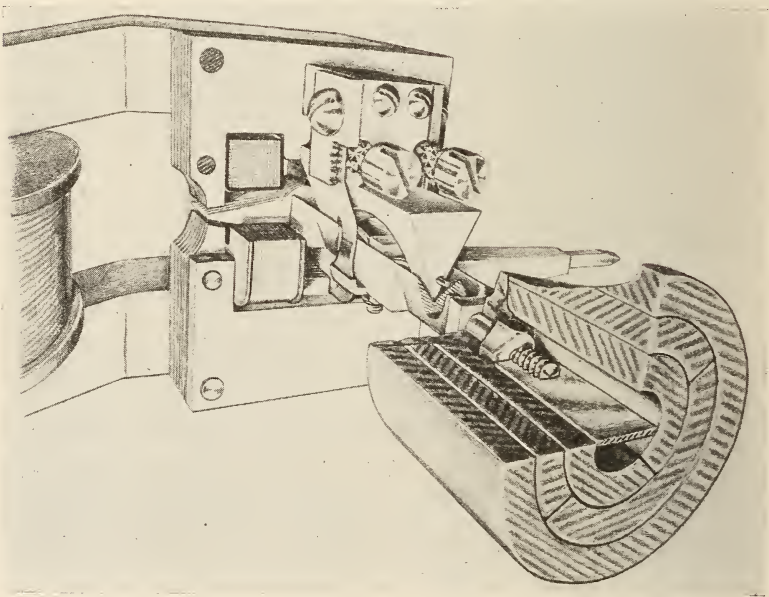


FIG. 12. A magnetic recorder.

apparatus for controlling the volume of a number of loud speakers. The potentiometer on the 8-B amplifier just described, makes it possible to vary the volume of all the loud speakers up or down, whereas, the Volume Control panel makes it possible to vary the volume of the individual loud speaker or groups of loud speakers.

At the top of the left hand frame-work is the power amplifier. This mounts four 50 watt tubes, and carries its own grid battery box, voltmeter and DC milliammeter.

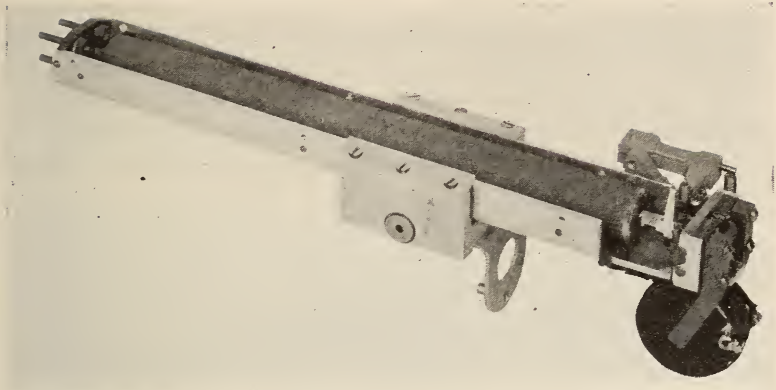


FIG. 13. A magnetic recorder.

Below the 10-A amplifier is the 6000-A rectifier, consisting of three units. The lower unit carries a rheostat for controlling the filament current of the large tubes. Above that is the unit which



FIG. 14. View of Vitaphone recording room.

mounts two large rectifier tubes for rectifying 110 volt or 220 volt AC to give the necessary plate voltages for the 8-B and 10-A amplifiers previously described.

Above this rectifier unit is the potentiometer filter unit. The filters are necessary to smooth out the rectified plate voltage so as

to eliminate objectionable hum, the potentiometer makes it possible to control the gain of the 10-A power amplifier at the top of the frame-work. The tubes used with the 10-A amplifiers require 750 volts DC, which is dangerous, hence the high voltage wiring is all protected to guard against accidental contact. Safety switches are provided so that the power is automatically cut off in case the apparatus is opened.

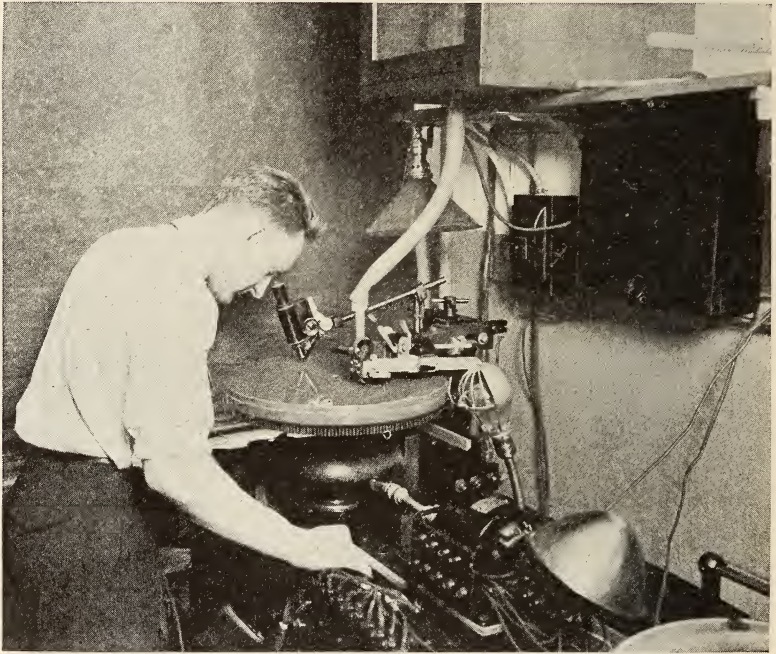


FIG. 15. Close-up of recording turn table.

Fig. 12 shows a line cut of the magnetic recorder. This is of the balanced armature type, and the method of pivoting the armature and the means by which the armature controls the stylus are shown. There is also shown here a mechanical filter, which has the property of suppressing certain frequencies. This is necessary in order to maintain a proper straight line characteristic which has already been discussed. This functions with physical vibrations in the same manner as electrical filters with alternating currents of various frequencies. The field is excited by an electro-magnet.

Fig. 13 shows what might be called a worm's eye view of a magnetic recorder, since the picture was taken from beneath to one side. The stylus is shown projecting at the bottom, and the energizing coil is shown on top to the left.

Fig. 14 is furnished through the courtesy of the Vitaphone Corporation, and shows a view in a recording room in one of their

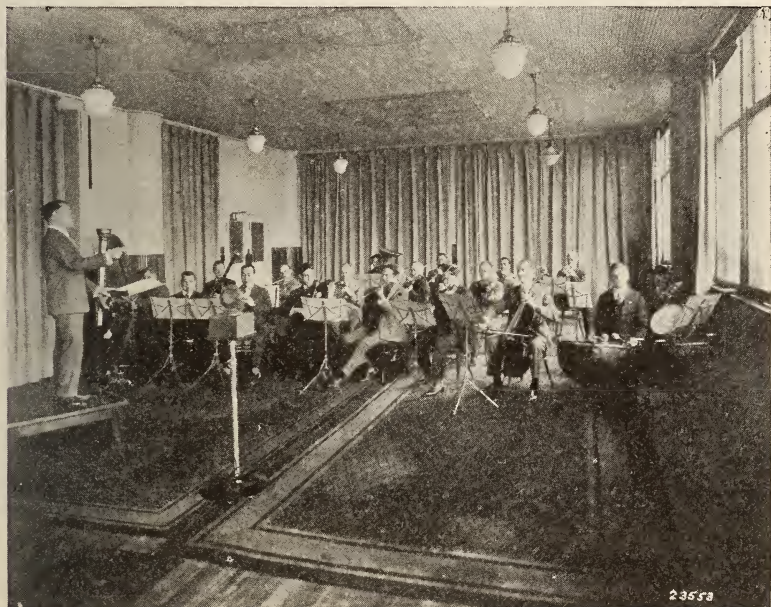


Fig. 16. Scene in studio using electrical method of recording.

studios. In the rear will be noticed two turn-tables on which the records are made. The panels to the right of the recorders mount amplifiers, switching panels and other control equipment.

Fig. 15 shows a close-up of the recording turn-table with wax in place during the operation of recording. An attendant is shown viewing the record-cut through a microscope. This is deemed advisable to insure that proper recording is being effected, and that the stylus is making sufficient, but not too great an excursion so as to cut over into the adjacent groove.

Fig. 16 is furnished through the courtesy of the Victor Talking Machine Company, and shows a scene in one of their studios using the electrical method of recording described above.

Fig. 17 is also furnished through the courtesy of the Victor Talking Machine Company. It shows a typical scene in one of their studios using the now discarded acoustic method of recording.



FIG. 17. Scene in studio using now discarded acoustic method of recording.

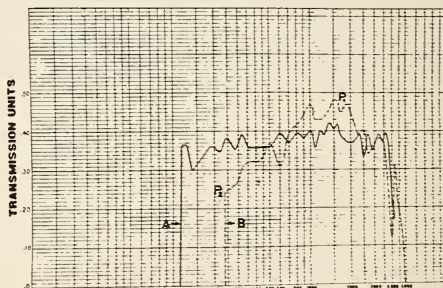


FIG. 18. Comparison of frequency characteristics of electrically and acoustically recorded records.

Fig. 18 shows the frequency characteristics of the output of new style phonographs with electrically recorded records and old style

phonographs using old acoustically recorded records. It should be noted that the improvement in the new equipments is due to adding a band of low frequencies and cutting off a peak in the higher frequencies.

Fig. 19 shows one of the balanced armature type of loud speakers used extensively in connection with Public Address systems. The construction is similar to that used in Radio Loud Speakers manufactured by the Western Electric Company. The diaphragm is of

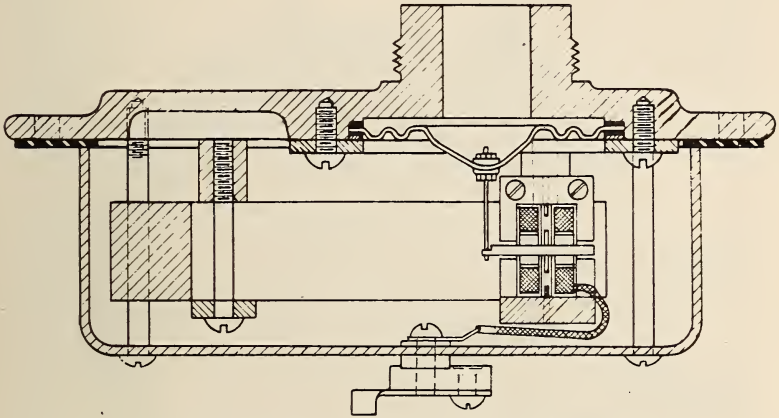


FIG. 19. Balanced armature type of loud speaker.

duralumin, the center of which is connected to one end of the balanced armature. This balanced armature construction is used in the recorder and reproducer as well as in this form of loud speaker. In the reproducer the movement of the armature by the needle following the groove in the record generates sound currents which are amplified and then connected into sound by the loud speakers.

Fig. 20 shows one of the Western Electric Company's newer types of loud speakers, and the one now used in Vitaphone installations. It is electro-magnetic, and requires an outside source of direct current for excitation. It is of the moving coil type, and has a stretched duralumin diaphragm. The efficiency of this loud speaker is considered higher than the one previously shown. Its characteristics approach more nearly a straight line.

Fig. 21 shows one of the horns used with the 555-W loud speakers in connection with Vitaphone installations, and is designed to give maximum efficiency with minimum distortion. Notwithstanding its

appearance, it is actually designed to give a straight line characteristic.

Fig. 22 shows diagrammatically a side elevation of a Vitaphone installation. This shows the installation of the amplifier equipment in the projector room with leads running to the loud speakers, one

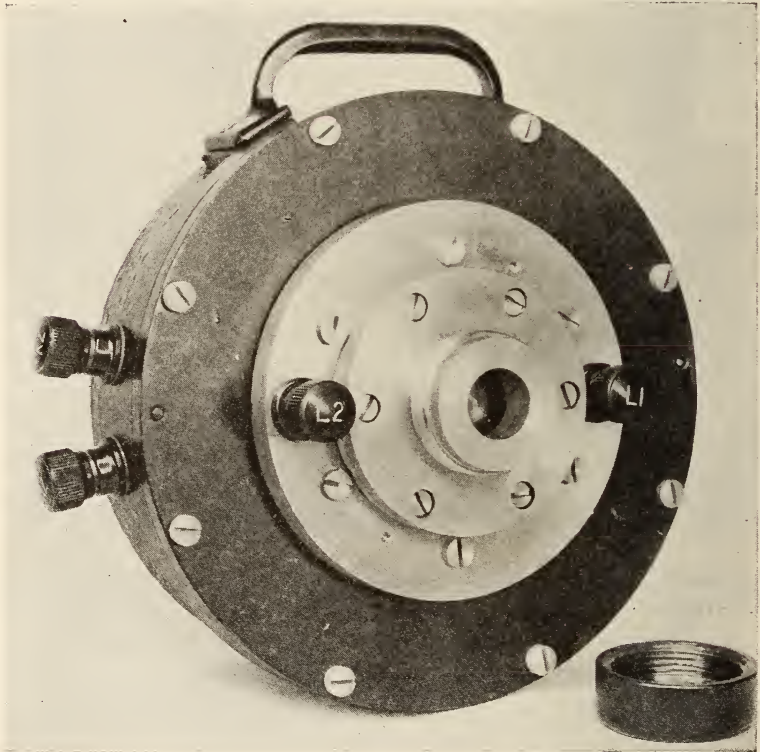


FIG. 20. Electro-magnetic type of loud speaker.

above and behind the screen, and one below immediately in front of the screen. Proper location and the number of loud speakers for a given installation depends on the size and acoustic properties of the theater.

Fig. 23 shows the Vitaphone equipment installed in connection with a Simplex projector. The motor *l* used for driving the projector and the turn-table is designed to operate on 110 volts DC or AC commercial service, and is provided with a special circuit by means

of which the speed of the machine is maintained at 1200 RPM. It is mounted on a substantial base *1-a*, supported by three telescoping legs by means of which its height may be adjusted. The control circuit is contained in a steel box *2*, and is connected to the motor by a multi-conductor cable encased in flexible conduit. A special $1/5$ H.P. shunt or repulsion type motor is furnished together with its control circuit, according to whether the power supply is a nominal 110 volts DC or AC.

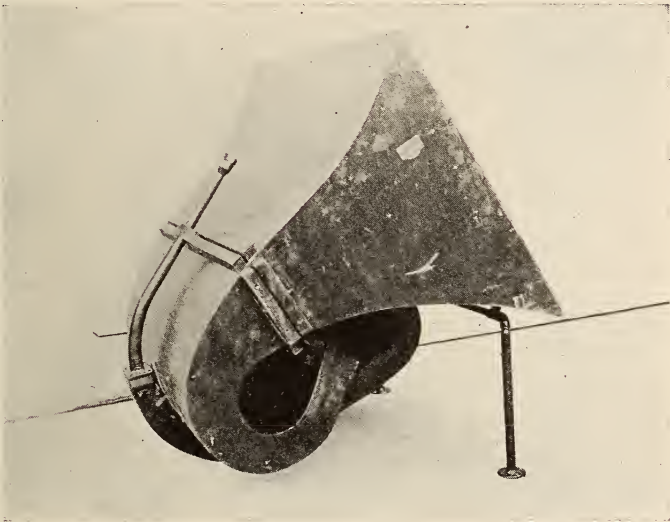


FIG. 21. Amplifying horn.

This equipment *3* consists of a drive or gear box *3-a* mounted on the same base as the motor and coupled directly to the shaft of the motor, a vertical extensible shaft *3-b* equipped with universal joints and a second drive *3-c* which is a bevel gear box and replaces the speed regulator of the projector machine. By means of these two sets of gears the speed is reduced from a motor speed of 1200 RPM to a speed on the projection machine shaft of 90 RPM, which corresponds to a film speed of 90 ft. per minute.

On the opposite end of the motor from the projector driving mechanism is the turn-table equipment, *4*. The turn-table mechanism is mounted on a heavy telescoping pedestal base *4-a*, the three supporting legs of which are provided with adjusting screws so that

it may be leveled. A worm gear mechanism is housed in a casting in the top of the pedestal. The shaft of the worm projects outward, and is connected to the driving motor shaft through a flexible coupling 4-b, designed to prevent the transmission of vibrations from the motor to the turn-table. The gear wheel which meshes with the worm carries a vertical shaft on which the turn-table disc is mounted. Between the gear wheel and the vertical shaft of the turn-table is a mechanical filter or "shock-absorber" consisting of light springs

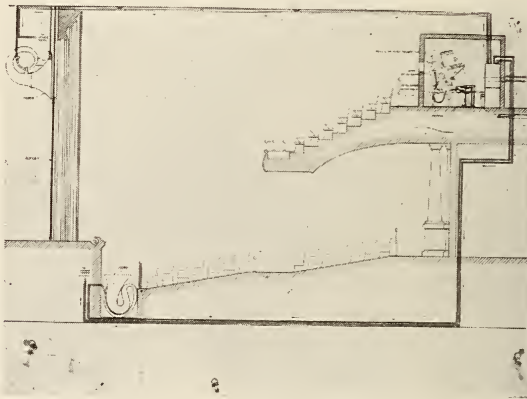


FIG. 22. Side elevation of Vitaphone installation.

designed to prevent the transmission of gear noises from the worm gear to the turn-table and thence to the record and reproducer. The worm gear ratio is such as to reduce the speed from 1200 RPM to $33\frac{1}{3}$ RPM, which is the correct turn-table speed.

The turn-table is designed to accommodate 18 inch records, and has a clamping device 4-c to hold the record firmly against its surface. A guard 4-d is provided to protect the rotating parts.

The operation of Vitaphone equipment naturally divides itself into two parts, (1) recording, and (2) reproducing. Briefly, the operation of recording equipment is as follows:

First, the set is prepared to meet all of the requirements for ordinary motion pictures in the usual manner. This, of course, must be done in a studio which is acoustically suitable, i.e., free from extraneous noise during the recording, and not subject to objectionable reverberations or echoes. The microphones are placed so as to pick up in proper volume the sounds which it is desired to record.

The film in the camera behind the shutter is marked, the recording wax is placed on the turn-table and the inter-locking electrical drive which maintains synchronism between the camera and the recorder is energized.

The recorder is lowered onto the wax disc and the motor started, and the act produced. The sound recording is effected from the center of the disc to the periphery instead of the reverse as in the case of commercial phonograph records. In order to insure proper amplitude, and to insure high quality, the recording is observed under a microscope during the process. The beginning of the cut on the inside of the record is marked by an arrow which will indicate the starting point of the record for reproduction. From here on the preparation of sound and film records for production follows standard procedures in phonograph and moving picture practice.

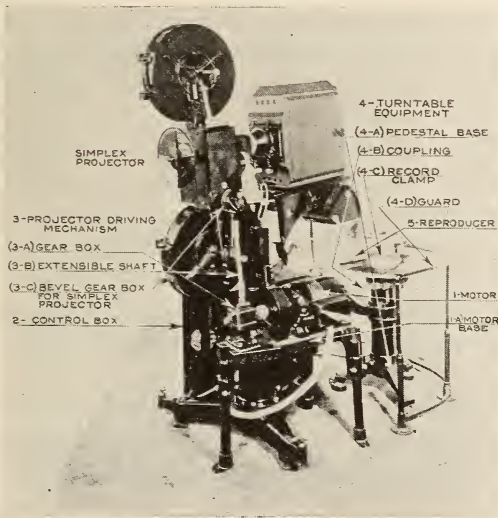


FIG. 23. Showing turn-table for record connected up with projector.

In reproduction the film is placed in the machine, the starting frame on the film which is marked "START" with the designating number of the film, is placed exactly in the center of the aperture of the motion picture machine when the shutter is in the open position. The corresponding sound record is placed on the turn-table with

the needle of the reproducer opposite the arrow on the inside groove. With the film and record thus set, the amplifiers should now be turned on, the potentiometer set to give the desired volume, projector light turned on and the starting switch on the control box operated. This starts both records simultaneously and the show is on.

Reference has been made to a photographic method of recording sound in contrast to that which has just been described. The Western Electric Company is now engaged in equipping the projector used by the Vitaphone Corporation so that it will accommodate "Movie Tone" film. This film carries the sound record photographed on its margin. "Movie Tone" is a trade name for sound motion pictures now being made by the Fox-Case Corporation, but not yet released to the public. It is contemplated, therefore, that future projectors will be provided with means for reproducing disc and photographic records in proper time relation with the picture. This will make it possible for any theater to reproduce Vitaphone productions and "Movie Tone" films. The Western Electric amplifiers and loud speakers will serve in either case.

"Movie Tone" differs considerably from the Vitaphone process. The camera which records the movements of the performers on the film is provided with means for varying the intensity of light falling on the margin of the film. The sound vibrations from the performers actuate a microphone, the same as that described for the Vitaphone. The output of the recording amplifiers, however, instead of actuating a stylus cause variations in the intensity of light falling on the margin of the film.

The presentation of a "Movie Tone" production is a reversal of the process just described. A standard film carries both picture and sound record, which is run through a motion picture projector to which has been attached a reproducing unit. This unit includes a light which is focused by a lens system through a narrow slit onto the sound record of the film. As the sound record on the film passes the slit it interrupts the constant light shining through it, setting up light variations corresponding to those photographed. The light falls on a photo-electric cell, which has the property of converting variations in light into electrical currents. These electrical currents are then amplified in the manner already described in connection with Vitaphone equipment.

DISCUSSION

MR. RICHARDSON: I would like to ask Mr. Rainey a few questions. First, with regard to the impression of the photographic record of sound on the film itself, is it not the fact that since the light source by which it is projected is itself stationary, any movement in the nature of a displacement of a film frame over the projector aperture would distort the sound? Second, is it not a fact that even the smallest possible amount of oil upon the sound record on the film would greatly impair or entirely ruin the sound effect of the portion upon which the oil lay? Third, is it not a fact that any shrinkage or stretching of the film stock, or the straining of the sprocket holes, or their abrasion through wear would affect the sound reproduction?

MR. RAINEY: I think I know what is running through Mr. Richardson's mind. I have heard demonstrations of film productions just as convincing in quality as that which you have just heard. The merits and demerits of one or the other of the two methods of recording and reproducing would form the basis for a long discussion, and I think it would be premature to start such a discussion at this time. The effect of oil and dirt on reproduction are practical problems which must be dealt with, and which do not appear unsurmountable.

MR. HILL: I should like to ask if the piano reproduction was a straight line reproduction from 16 to 5,000.

MR. RAINEY: Approximately yes. I was trying to get this idea home when I called that jagged line a straight line characteristic because the human ear cannot always recognize deviations from a straight line characteristic. The reproduction to which you have just listened was good. Its characteristics are probably as near a straight line as some of the straight line characteristic curves which were shown on the slides. The output of the horns you heard had a very good straight line characteristic, and yet the production which you heard in the particular place where you were sitting may not have been as good due to the peculiar acoustics of the room and the particular place in the room where you were listening. The other end of the room behind the horns might easily produce a detrimental effect.

PHYSIOLOGICAL EFFECTS OF LIGHT

MERRILL J. DORCAS*

IN SUPPLYING artificial illumination for a motion picture studio the primary consideration is to secure the quantity and quality of light that will have the desired effect on the film. This subject has been dealt with in many papers and discussions. In the present paper the effect of the light on the actors rather than the film will be considered. I wish to call your attention to two of the many known physiological effects of light on human beings. Many physicians have become interested in these physiological effects in the last five years. Their research work has enabled us to form certain definite ideas that might be important in some applications of light in studios.

One of the earliest noticed physiological effects of light in studio practice was the irritation caused by the ultra-violet light from arc lights. This irritation was particularly noticeable in the cases where conjunctivitis or "Klieg eye" resulted. This was annoying, possibly dangerous, and resulted frequently in lost time by high salaried employees. Klieg eye has now disappeared in most studios where glass screens are used. Consideration of the phenomena involved from a theoretical viewpoint indicates that this method is sufficient for complete protection and is probably the best possible method of preventing irritation of the eye. The theory is, briefly this: Light of the shorter wave-lengths which causes eye burn has no effect on the film. Ordinary glass transmits practically all the photographically active light and none of the injurious light. This statement is not absolutely exact but the variations from it are minute. Ordinary glass transmits light of wave-lengths longer than about 3400 ÅU. It absorbs light of wave-lengths shorter than this. Light of wave-lengths shorter than 3400 is very weak in its photographic effect though it is possible to photograph such light, if sufficiently intense, down to wave-lengths as short as 2400 ÅU, if no lenses are used. Ordinary photographic lenses, however, are made of glass and therefore in any case will transmit to the film only that quality of light which the glass screen is capable of transmitting. Furthermore the reflecting power of common substances for these short waves, or,

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as we might think of them, these colors of ultra-violet, is so different from that of visible light that if it were possible to make use of them by inserting quartz lenses in the camera very unnatural tones would result. For example, human skin absorbs rather than reflects light of wave-lengths shorter than 3200 ÅU and would therefore appear black if photographed with only short wave light. It is therefore advantageous to filter out this light if panchromatic films are to be used and if little or no make up is to be required of the actors. Light of wave-lengths longer than 3400 is reflected by most substances in a manner similar to visible light and we can therefore profitably use all the light that will go through ordinary glass.

Any glass will reflect about 8 per cent of light of all wave-lengths and colors from its two surfaces. The glass screen therefore diminishes the total intensity of illumination by this amount. This is scarcely noticeable photographically. The slight loss in intensity is balanced by the advantage of the slight diffusion possible with the glass screen. To briefly sum up this phase of the discussion, the irritation to skin and eyes is caused by light from 2700 to 3200 ÅU. It can be filtered out by ordinary glass, which is as opaque to this range of ultra-violet as a sheet of steel. By filtering it out we lose but a small percentage of photographic power due to reflection losses from the glass screen. Therefore glass screens in practice will satisfactorily prevent Klieg eyes and there is no theoretical reason to think that this method can be improved upon.

Light of various wave-lengths has many other complex physiological results which are just beginning to attract serious attention and general clinical study. One well known physiological action is the effect of excessive infra-red or heat rays in producing sunstroke effects. Thus far in studio practice the intensities of illumination employed have probably not been sufficiently high or of sufficiently long duration to make such effects possible. They may, however, prove to be a limiting factor in the quality and intensity of illumination which can ultimately be used with safety in studio lighting. The symptoms following excessive exposure to near infra-red energy, which always accompanies visible light while commonly known as sunstroke, is in reality a heat stroke. It is due to the great penetrating power which this kind of radiation has for the body tissues. It passes into the body for a considerable distance before being absorbed as heat. This light is technically described as radiation of wave-lengths of about 6500 to 42000 ÅU. If of sufficient intensity

the effects may be many and profound. One of the most serious is irritation of the membranes covering the brain and spinal cord; in other words, a form of meningitis. In the tropics exposures of the unprotected body for 5 minutes to direct sunlight has been reported as fatal. Protection is secured only by pith or cork helmets and spine pads. The fact that in the temperate zones sunstroke is rare and in the tropics great precautions are necessary gives us a measure of the intensity limits of this radiation which is safe for human beings.

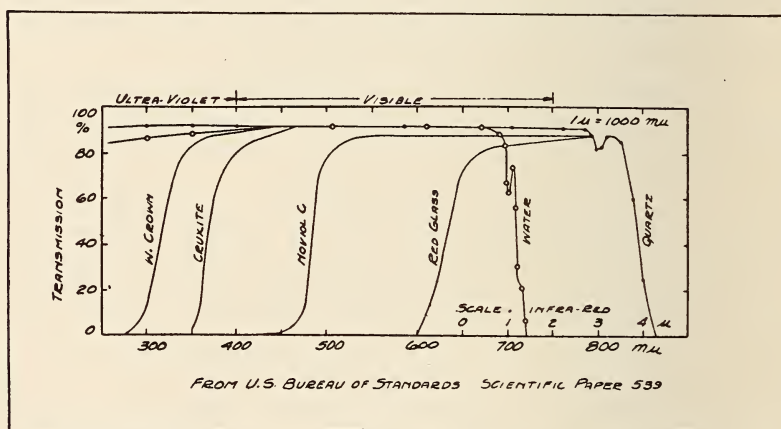


FIG. 1. The Spectral Regions Transmitted and Absorbed by the various screens.

Modern studios already are using intensities of visible light which approach that of noon summer sunlight in temperate latitudes. Scientists have determined the amount of penetrating radiation or heat content of such sunlight. This quantity of heat radiation therefore approaches the known limits which the human body can endure with comparative safety. Recently quantitative measurements of the comparative light and heat content of the radiation from different types of light-sources have become available. From the point of view just discussed, let us examine the various important artificial light-sources for the relation between the amounts of visible light, namely the radiation between 3700 to 6500 ÅU with the corresponding amounts of heat or infra-red radiation, that is, the amounts between 6500 to 42000 ÅU.

These figures are from some work recently done at the Bureau of Standards by Coblenz et al and reported in Scientific Paper 539.

The figures were obtained by means of a thermopile and the following screens.

Spectral Component Radiation in Per Cent of the Total to 120,000 A.U.

Source	1700	3200	3700	4800	6500	14000	42000
	to 3200	to 3700	to 4800	to 6500	to 14000	to 42000	to 120000
Sun Washington June 28, 1926 11 A.M	1.8	3.2	13.3	22.0	39.5	19.7	0.5
122 Ampere High Intensity	1.2	2.5	11.6	14.2	29.2	27.8	13.5
29 Ampere DC White Flame	2.3	1.7	8.6	8.4	21.0	33.0	25.0
Neutral Core Negative Solid Positive 21 Amp. 1500 Watt	0.9	1.2	1.9	2.9	20.7	56.7	15.6
Type C incandescent	0.0	0.2	1.0	3.8	29.8	54.2	11.0

From Bureau of Standards Scientific Paper 539.

The studio problem is to secure a light which is photographically active and approaches the intensity of sunlight. The heat rays which are physiologically dangerous when present in excessive amounts should not greatly exceed the quantities found in sunlight in the temperate zones. It will be seen from the tables that noon June sunlight is approximately 35 per cent light and 60 per cent heat using these terms in the above defined sense. The light from a high intensity arc lamp using 125 amperes is similar in its composition, that is 26 per cent light and 57 per cent heat. If transmitted through a glass screen the ratio would be very nearly the same because ordinary glass transmits energy of all wave-lengths from 3400 to 45000 approximately, except the 8 per cent that is reflected. This reflection is about the same for all wave-lengths, therefore the ratios of light to heat, when we define them as we have in this paper, are unchanged. The ratio of light to heat for a source such as the high intensity arc

lamp, being similar to sunlight, it can be employed in intensities which give the similar visual and photographic effects with no greater hazard from the heat rays than is common to June noon day sunlight.

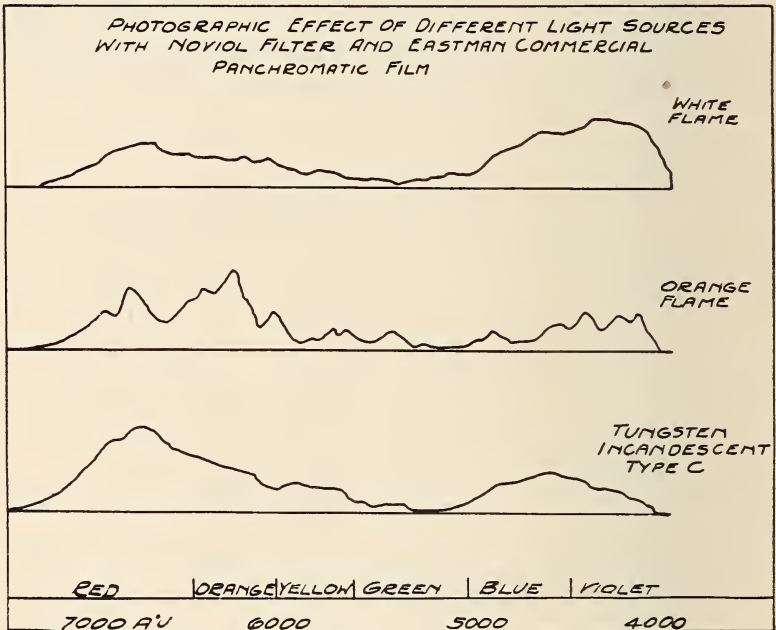


FIG. 2. Photographic effect of different light sources with Noviol Filter and Eastman Commercial Panchromatic Film.

The low intensity flame arcs show a slightly less favorable distribution of radiant energy, the exact quality of the radiation varying with the lamp design and conditions of operation and with the type of carbons employed. A typical case is the 30 ampere white flame arc with reflector which on direct current shows 17 per cent of photographically useful light to 54 per cent of heat radiation. As in the previously described case of a high intensity lamp, the use of a glass screen does not sensibly change this ratio. In this case for a visible illumination equivalent to sunlight the heat radiation would be nearly twice as great as that normal to temperate latitudes.

Next we come to the so-called neutral carbon arcs in which the principal source of radiation is the incandescent carbon craters,

and our table, for example, shows that a neutral cored carbon arc trim on a small current of 20 amperes gives 4.8 per cent light and 77 per cent heat. A similar situation is also found with the incandescent tungsten lamp. With the same instruments and method of measuring, a 1500 watt gas-filled "C" type tungsten incandescent bulb, operating at its rated voltage, will give about 4.8 per cent of light and 84 per cent heat, a ratio seven times as high as that of the high intensity arc, and nine times as high as is found in sunlight. This suggests, therefore, that if visible light approaching sunlight were to be supplied by incandescent sources of these types, the quantities of near infra-red energy might reach such values that human beings could not safely work in them for any but very short periods. It is at least safe to conclude that where intense illumination is required, the employment of incandescent sources containing a high percentage of infra-red would introduce certain new problems and hazards requiring careful clinical attention and investigation. By physical methods it may be possible to overcome a portion of these difficulties. We have seen that the undesirable ultra-violet can be filtered out of the radiation by glass screens. Some infra-red can also be removed in a similar manner. Our table shows that the particular portion of the infra-red spectrum that we are considering can be divided into two parts by means of a water-cell or screen, which consists in this case of a layer of water 1 centimeter thick. Such a screen absorbs the very long wave-lengths below 42000 ÅU and thereby removes about 33 per cent of the total heat from sunlight. For the artificial sources considered, the absorption of heat rays is as follows: 49 per cent of the heat rays from the high intensity arc, 61 per cent from the 30 ampere white flame, 73 per cent from the neutral core spotlight, and 65 per cent from the incandescent bulb.

Immersing an incandescent bulb in a water bath or allowing water to flow over the bulb or over a glass screen in front of the bulb would therefore remove considerable percentages of the infra-red energy. The portion of the infra-red absorbed by water is physiologically speaking the least dangerous however, since the human tissues are themselves chiefly water and therefore these rays have comparatively low penetrating power. Because they are absorbed near the surface of the body they give the strongest effect of sensible heat to the skin and therefore a warning of their presence in undue excess. Therefore the water screen would serve only to remove the energy of low penetrating power, but would not diminish the near infra-red

radiation which can penetrate deeply. It is possible, however, that suitable glass screens could be devised which would filter out a portion of this near infra-red without absorbing too much of the visible light.

Recently it has become possible to duplicate the color ranges of the incandescent bulb by the light generated in the high intensity arcs while still retaining the high photographic efficiency and comparative coolness of this type of radiation. The accompanying chart shows the photographic effect on Eastman commercial panchromatic film of light from a new carbon electrode and an incandescent bulb. It is seen that the relative effect of the reds and yellows compared to the blues and violets is about the same in each case.

For the present, therefore, in so far as it may be necessary to employ intensities of illumination approaching or exceeding sunlight in studio work it would appear that the high intensity carbon arcs modified in color if necessary for panchromatic films, constitute the safest known source of light now available with the exception of the sun.

Summary

Two physiological effects of the radiation from artificial and natural light-sources are discussed, one arising from the ultra-violet, the other from the infra-red regions of the spectra. Klieg eye, once a serious problem for the actors, has been satisfactorily solved in most studios by the use of glass screens. This protects the actors from the chemically active shorter wave-lengths, which never reach the photographic film in any case because excluded by the camera lenses. The method involves only a slight loss in desirable radiation through reflection losses from the screens employed.

A less well-known hazard is the possibility of heat stroke effects in the presence of sufficiently high concentrations of the extremely penetrating infra-red rays. With the tendency toward concentrations of artificial light in studio work approaching sunlight in intensity recent measurements have shown that certain incandescent sources will contain infra-red radiation in amounts that are far from negligible the possible hazards of which require careful investigation. In this respect it appears, (a) that incandescent sources such as the solid carbon or neutral cored arcs, and the filament lamps constitute a class of artificial illuminants which have the smallest factor of safety; (b) that the low intensity flame carbons occupy an intermediate and fairly favorable position; and, (c) that the high intensity arcs closely

approaching sunlight in radiation quality constitute from the physiological standpoint the most desirable form of artificial illumination, where concentrations of light of the order of noonday sunlight are required.

DISCUSSION

MR. L. A. JONES: I should like to point out, in connection with the author's statement relative to the spectral distribution of sensitivity of photographic materials, that they are in fact very sensitive in the short-wave-length region. It is customary to define sensitivity in terms of energy per unit area since in dealing with ultra-violet radiation it is impossible to specify sensitivity in terms of visual units. Defined in this manner sensitivity is practically constant in the region between 250 and 350 $m\mu$. For radiation of wave-length shorter than 250 $m\mu$ the sensitivity decreases gradually while for radiation longer than 350 $m\mu$ it decreases rather rapidly becoming practically zero at 550 $m\mu$ for ordinary blue sensitive plates and films.

I believe the author's discussion of the problem implies that all radiation of wave-length longer than 340 $m\mu$ is useful for the reproduction of the visual impressions. The maximum of visibility for the human eye is at 550 $m\mu$, decreasing rapidly for shorter and longer wave-lengths. Assuming the sensitivity at the maximum to be represented by 100 per cent, the sensitivity at 400 $m\mu$ is only one-tenth of 1 per cent. It is evident that the use of radiation of wave-length 400 or shorter can only produce very marked distortion of the brightness scale in colored objects. If it is desired to obtain an approximately correct reproduction of the brightness factors all radiation of wave-length less than 430 should be absorbed.

MR. BUTTOLPH: May we have that first chart showing the energy distribution of various sources? In the original paper from the Bureau of Standards, by Coblenz, Dorcas and Hughes, this data was also given for a quartz mercury arc and the relative energy distribution of this arc differs so slightly, so far as the division between the visible and infra red is concerned, by so slight an amount that I believe this chart would be highly illuminating if the data for the quartz mercury arc were added. Is it possible to have that done? As given in this table, reading from left to right, the percentages are 5.7 for 170-290, 2.8 for 290-350, 2.5 for 350-450, 6.7 for 450 to 600, 3.2 plus 20.5 plus 58.6 for 600 to 12,000. Adding these last three figures, as was done here, for comparison between the infra red and

visible you have approximately a total of 82 as against 60 for sunlight and 95 for the gas-filled tungsten lamp. This energy distribution and the further localization of the visible in a few lines at the maximum of visibility is the explanation of the claim often made that for a given intensity, either visual or photographic, by mercury vapor lighting you have a relatively small amount of total energy entering the eye or camera as the case may be.

MR. BURNAP: I should like to ask Mr. Dorcas if he knows at what efficiency the 1500-watt incandescent lamp was operated in making these comparisons.

MR. DORCAS: I don't know the lumens per watt; it was labeled 115 volts and ran at this controlled with a voltmeter.

DR. GAGE: It has been questioned in the literature whether infra-red might be harmful, and I think we have here an indication in tropical countries of heat stroke due to penetrating radiation. I should like to inquire—perhaps some of the cinematographers with experience in the tropics could help us in this—as to whether the heat stroke does not also require that the temperature of the air be high; that is, if the body cannot take care of a considerable amount of red radiation if the body is kept cool by the air? That factor would certainly have a considerable interest in operating in the summer when the air temperature of the studio gets hot.

MR. GREGORY: I have had several experiences to make me believe that the surrounding air temperature does not have any great effect. I have seen sun stroke among snow shovelers on the mountain top where the temperature was low but the sunlight intensity very high and have worked near the equator with blondes, who were made sick for days whereas those protected by the pigmentation of the skin were unaffected.

A MEMBER: As the previous speaker pointed out, infra-red penetrates and appears in the body well below the surface, and the physiological difficulty is to get that heat out. It can be demonstrated in the laboratory that the blood temperature of the body can be raised by radiant heat corresponding to blood elevations in cases of fever, which cannot be done by hot air or a hot bath.

MR. JENKINS: A multiplicity of copper screens spaced apart will take out heat much faster than it takes out light, and that was strengthened in my mind by the fact that chains are hung before large furnaces to keep the heat from the men, and this led to the testing of copper screens spaced apart in order to get a greater sub-

traction of heat than of light in an arc lamp, which was the source used.

MR. MAYER: Apropos of Mr. Jenkin's comment, I experienced the same condition. We use a 500-watt over-voltaged lamp which must be over-voltaged, and after a lot of experimenting a fine mesh screen of copper made a cooler beam on the subject and diffused the light satisfactorily.

At a recent meeting of the Société Française de Physique M. Chrétien showed the Hypergonar, a supplementary afocal system, composed of cylindrical lenses, which can be used for compressing the horizontal scale of a motion picture to half normal, while retaining the vertical scale, thus enabling twice the field to be recorded. The picture thus deformed is restored to its normal dimensions by placing the same system in front of the projection objective. M. Kitrosier showed the Polytypar consisting of a semi-transparent platinized mirror, that can be placed in front of the camera lens so as to reflect the image of a miniature scene or model, while the actors or the like may be taken direct. The image of the model is located at any convenient distance by an achromatic and aplanatic collimating lens. Masks may be used to block out such parts as desired. This has been successfully used in a picture not yet released. (Sci. Ind. Phot. 1927, 7A, 64.)

SOME PATENTS FOR TRICK PHOTOGRAPHY

E. J. WALL

SOME attempt has been made to collect a few patents relating to this subject, mainly it must be confessed from English sources. To make a complete list of the patents of all countries would need rather more time than I have had a chance to give to it.

CLIVE, J. C. E. P. 2, 139-1855. A portrait or group is taken on glass and the background removed. A scene to form the background is then taken on the other side of the glass or on a separate sheet, which is placed behind the first. Figures or objects taken at different times can be brought into one picture.

LAROCHE, W. S.—E. P. 820-1866. Placing in front of and close to sitters a screen or frame covered with canvas with an opening cut in the latter. The opening may be surrounded with ornamentation. By means of the ordinary camera and processes, the frame and sitters are photographed at the same time, the result being a composite picture with portrait and ornamental frame complete.

HEMERY, T. G.—E. P. 89-1870. Various methods of obtaining impressions of two sitters on one plate are detailed, but one that may be of interest is as follows: one of two similar impressions of one figure is rendered opaque and is placed in front of a second plate in the camera so as to print a transparent figure thereon. The second plate and the unused impression of the first figure are combined to afford a single negative. According to another method the background in one negative is transparent, and opaque in the other and the two are superposed and a transparency made of the combination.

In 1875 an English provincial photographer, named Tilley,¹ advertised that he had a new invention of photographic combinations and that while practically defying one and all to discover his method, announced his intention of giving his system free of charge to anyone who discovered his secret within six months. Soon after J. Werge,² a well known figure of the early days, described a method of putting in a background by photographing a sitter against a dark plain ground and using another and paper negative of the desired background from which the figure was cut and superposing on the original negative for printing. Twelve months later Tilley's secret was out, for the patent was published³ and it resolved itself into photographing a sitter first against a dark background, then photographing the desired ground on the same plate by the interposition of a positive just in front of the plate, the sitter still retaining his pose, and being thrown into comparative darkness by curtains.

E. Dunmore⁴ described the use of separately taken landscapes or interiors for this work, as employed by a Mr. Edge. The latter in describing his work⁵ said: "The *carte-de-visite* photograms of figures with natural backgrounds, made by me some 20 years ago, were printed from two different negatives; the figure and foreground from one, and the natural background from the other." Some excellent pictures are reproduced. Practically the same method was patented by L. Schulze.⁶

In 1894 F. F. Weeks and J. Riley⁷ patented a method of posing a living or artificial model in front of a plain white background. The negative was then blocked out, leaving nothing but the subject visible. An enlargement was made and scenic effects, etc., were hand-drawn on that. This print was then photographed to make the "working negative." The patent is very comprehensive and worth careful perusal.

There seems to be a curious gap here, for the next patent that is of any interest was granted to F. J. Dischner⁸ which is fully described and illustrated in the *British Journal of Photography*. This is again the use of black grounds and a transparency of the natural scene, etc., in contact with the plate while the sitter retains his pose against the white ground. This is essentially the older process without, so far as I can see, any point of novelty. A precisely similar patent was granted to F. J. Mohr and J. Vincent.⁹

The most important reference that I have been able to find is to "an apparatus for making composite negatives direct in the camera. Sold by Halford & Thompson, 4 Broadway, Hammersmith, London, W."¹⁰ This would seem to have been invented by W. B. Henderson¹¹ and is officially described as "a shutter or screen for exposing a plate in sections," and the specification itself does not give one any idea of the possibilities as outlined in the *British Journal of Photography* as follows:

"The apparatus consists of a framework very similar to the skeleton of an Eastman roll-holder, which is mounted on a square frame by struts which allow its distance from the supporting frame to be adjusted. The frame fits into the back of the camera, and the roller mechanism is thus supported inside the camera at a distance of say, 3 inches to 4 inches from the focusing screen. It is, however, but the means of bringing into action the essential part of the apparatus—viz., a flexible band wholly of black paper with certain apertures in it, or partly of the paper and partly of celluloid, for the distinct purposes which will be seen in a moment. In either case the band is wound across the space between the two rollers, and is caused to halt at any desired point by register marks on its edges and

one center mark on the framework which supports it." The method of obtaining three images on the same plate are then given it being stated that they "merge into each other without the sign of a join, so that all three may be printed as a complete photograph, or each one completed separately." Then the method of securing a frame round a portrait is given. But the most interesting part is as follows:

"It is, however, in the use of the apparatus for employing miniature accessories as full sized backgrounds that the most ingenious application of the apparatus is found. The manipulation is precisely the same as just outlined, that is to say, the sitter is photographed through a mask, any size and shape thought desirable, the complementary disc wound into place, and a second exposure made on the miniature model of a room, a doorway, a wall, or any other object thought suitable as a background or accessory. The blinds, both all-black and black and transparent are obtainable in considerable variety, devised to serve the photographer in the production of commercial styles of portrait. We have not spoken of the amateur model of the apparatus devised to fit on the lens hood, but it has certain valuable properties for landscape photography in the way of equalizing exposures and even producing combination photographs in the field."

This instrument was called the "Thaumatoscope" and was sold for 30 shillings (\$7.50). It would seem to me to be a very distinct anticipation of many of the more recent devices used for ciné work.

We then come to the patents of H. Sontag,¹² of Erfurt, Germany. In these the background was projected on to a translucent or transparent screen behind the sitter. After detailing the defects of prior methods the specification reads:

"The drawbacks in question are obviated by the new process which enables the object and the background projected to be photographed with only one exposure of the plate. The object can be lighted both by daylight and by artificial light. The process itself by which this result is obtained, chiefly consists in the picture forming the background being projected on a screen colored with a color which has slight chemical action, such as yellow, red, green or the like, the object to be photographed, suitably lighted, being in front of the said screen, and being photographed with the background projected by a single exposure of the plate."

It is unnecessary to quote further; enough has been said to show the purpose of the invention. But a further reference¹³ to this patent gives some added information.

E. NEAME (E.P. 153,111, 1919)

Elaboration of the above method.

So far all these patents relate to stills, not ciné work. You may or may not consider them important, but the only excuse I make for abstracting them is that I consider that if a process has been applied to ordinary photography, there is absolutely no invention in applying

it to cinematography. If I am wrong, then we have a somewhat absurd position, that is best illustrated by a supposititious case. Thus, the intensification of the silver image with lead salts has been known since about 1876, yet so far as I know, has never been used for ciné work, hence it can be patented as an invention when used in this way, although known for 56 years.

The following patents are applicable essentially to cinematography:

Patents relating to the making of Composite pictures.

- DAWLEY, J. S. (U. S. P. 1,278,117, 1918) Introducing backgrounds with a sheet of glass, acting as a light-splitting mirror through which the images of actors are transmitted direct, while the background is reflected.
- BROWNLEY, L. E. (U. S. P. 1,355,648). Making stencils photographically from negatives and combining silhouette or detail figures with a background.
- PRESICCE, G. DE L. (U. S. P. 1,358,110; E. P. 144,408, 1919.) Reflection of ciné pictures by large mirror to camera, with actors between mirror and camera.
- FLORES, U. (F. P. 511,168) Scenes and backgrounds projected on to suitably placed screens.
- BEHRENS, J. (D. R. P. 323,939) Background projected on to translucent screen, recalling Sontag, etc.
- PETRA AKT. GES. (D. R. P. 326,527) Ditto.
- HALL, W. L. (U. S. P. 1,372,811) Miniature paintings placed in predetermined places and taking them with portions of scene not obscured by miniature.
- SMITH, H. A. (U. S. P. 1,394,797) Projected images which may be of objects at different distances.
- GOETZ, H. I. (E. P. 169,233) Making silhouettes, as outlined in some of the early still patents. For moving pictures, two negatives are simultaneously obtained, one through a filter of the same color as the background, the other with complementary-colored filter.
- RUTTMANN, W. (D. R. P. 338,744) Three transparencies between the camera and a light. One is fixed, the second adjustable in its own plane and the third adjustable to and from the camera.
- BARKER, D. (E. P. 186,189) Making masks and using them before a background.
- COPIER, A. C. (E. P. 186,649) Method similar to Weeks & Riley, of 1894.
- CAPELLANI, P. (F. P. 548,352) Mirror system for introducing pigmy images.
- MICHELER, H. (D. R. P. 379,376) Inclined transparent mirror superposing a second scene on principal one.
- DOUGLASS, L. F. (U. S. P. 1,438,906; 1,477,999; 1,504,328; 1,531,693; 1,532,236; 1,591,296; 1,424,886; 1,482,068; 1,482,069; 1,482,070; 1,508,509; 1,543,065) All refer to lenses, or prisms to obtain two images on the one picture space.
- GRIFFITH, D. W. (U. S. P. 1,476,885) An artificial scene built in miniature outside a window, with actor in front of window. Separate lighting for actor and scene.
- KESSEL, H. VON (E. P. 219,993; D. R. P. 399,652) Practically making silhouettes by the use of two backgrounds and combining with the object negative; variant of the very early types.

- DRIGER, J. (F. P. 579,605) Trick camera with two lenses at right angles to throw different images on both sides of the same film gate.
- ARMANI, E. (F. P. 585,759) Apparatus for taking and showing trick pictures.
- WITHERS, J. S. (E. P. 233,654; 234,542) Part of object only erected and reproduced by mirror having a contour corresponding with part of the object on a reduced scale, the remainder of the scenery being arranged behind the mirror or as a picture so that when the two are combined a complete object is reproduced.
- WILKÉ, N. and P. MININ. (F. P. 588,560) Use of miniature sets.
- ANDERLE, R. (D. R. P. 416,582) Stand for making trick pictures from several negatives.
- GRIFFITH, D. W. (U. S. P. 1,554,210) Gauze curtain interposed between foreground and background.
- SCHÜFFTAN, E. (U. S. P. 1,569,789; 1,601,886; 1,606,482; 1,606,483) Use of one or more reflectors, miniature sets etc.
- BARTHOLOWSKY, J. (U. S. P. 1,574,464) Scenery on a reduced scale above the level of moving objects.
- SEITZ, J. F. (U. S. P. 1,576,854) Specially prepared masks so that individual frames may be printed with scenes taken at different times.
- KOHLER, W and E. SCHÜFFTAN (D. R. P. 428,589; 429,753; 429,754; 429,755) Object placed behind a perforated mirror which reflects another object on different scale.
- WILLIAMS, F. D. (U. S. P. 1,589,731) Projecting part of a view, drawing in the remainder of the scene and photographing the result. Cf. Weeks and Riley 1894.
- NEPPACH, R. and W. VOSS (F. P. 604,472; D. R. P. 431,572; 432,133; E. P. 254,925) Transparencies of scenes which may be interposed as desired.
- CONTINENTAL AND OVERSEAS TRUST (F. P. 611,746) Adjustable mirrors that may be of multiplying type so as to make a few appear a crowd.
- AKTIEN-GESELLSCHAFT F. SPIEGELTECHNIK (E. P. 230,454; 255,061; D. R. P. 407,592; F. P. 571,567; Cf. E. P. 233,645; 234,542; F. P. 594,480). Mirror so near camera that the outline through which the part scene is transmitted is not sharp; the outline may be an irregular edge of reflecting coat.
- ANDERLE, R. (D. R. P. 416,582) Scenes drawn on two bands differently illuminated and combined by mirror systems.
- TWELE, O. (D. R. P. 404,511) Miniature mirror images of objects taken with models.
- THOMS, P. (D. R. P. 396,139) Modification of Sontag's process.
- LEVENTHAL, J. F. AND M. FLEISCHER (E. P. 117,839) Enlarging ciné film, altering these where required and photographing down again.
- ENGELSMANN, A (D. R. P. 409, 314) Built-up scenery with mirror reflecting a view.
- DAWLEY, J. S. (U. S. P. 1,463,802) Sitter taken against black background and another ground obtained by second exposure.
- SUTCLIFFE, G. H. (E. P. 175,020) Transparent mirror at angle of 45° in front of lens reflecting background, scenes or ciné picture to film at same time as real picture is taken.
- HAMMERAS, O. R. (U. S. P. 1,540,213) Painted scenery on glass plate in front of fixed scenery.

- SCHOLL, E. (U. S. P. 1,572,315) Making masks for multiple exposures photographically, presumably on metal.
- BAKER, F. F. (U. S. P. 1,610,410) Making mask photographically and combining with other films for a final picture, calls for the use of three films besides the final one.
- DUNNING, C. D. (U. S. P. 1,613,163) Using a positive with toned shadows and highlights of neutral tint in front of film during exposure to a scene, which has a background complementary to that first used.
- SEITZ, J. F. (U. S. P. 1,616,237) Making enlargement of picture and building out parts to produce proper shadows.
- SCHÜFFTAN, E. (U. S. P. 1,613,201) Two cameras at an angle to one another with reflecting surface at the intersecting plane, so that one scene is reflected into one camera and the other taken direct. A complementary mask eliminating any desired parts.
- KOHLER, W. (D. R. P. 409,974) Combination of natural scene with copy of another, the latter being placed in film gate.
- SCHÜFFTAN, E. (U.S.P. 1,627,295) Two lenses at about 45° to one another registering direct scenes and reflected images of glass on the same frame of a film; passing at right angles behind two objectives.

¹ Brit. J. Phot. 1874, 21, 376.

² Ibid. 405, 430.

³ E. P. 635, 1875; Brit. J. Phot. 1875, 22, 449.

⁴ Brit. J. Phot. 1875, 22, 487.

⁵ Photogram, 1897, 4, 65.

⁶ D.R.P. 100, 428, 1897.

⁷ E. P. 8,615, 1894.

⁸ E. P. 27,088, 1905; Brit. J. Phot. 1906, 53, 302, 346, 416, 472.

⁹ E. P. 21,781, 1906.

¹⁰ Brit. J. Phot. 1907, 54, 927.

¹¹ E. P. 21,950, 1905.

¹² E. P. 4,609, 1912: Brit. J. Phot. 1912, 59, 607, 619.

¹³ Eder's Jahrbuch, 1915, 29, 58.

AIR CONDITIONING AS APPLIED IN THEATERS AND FILM LABORATORIES

D. C. LINDSAY*

DURING the past six years approximately two hundred theaters in cities well distributed throughout the United States have invested in air conditioning systems. This equipment is distinguished from the ordinary fan ventilation and heating equipment by the fact that it provides for cooling the air during the summer and, what is even more important, offers means of effectively establishing and controlling the condition of humidity.

Assuming that the investment has proven profitable to these two hundred houses, there are perhaps fifteen hundred theaters in the same class which are immediately prepared to add such equipment or should make serious investigation of the relative costs and profits.

This number will be considerably enlarged as the cost of cooling and air conditioning equipment is reduced through standardization and simplified methods. Already such a trend is evident, for a fair portion of neighborhood houses and a few theaters in smaller cities are now among the so-called air conditioned theaters.

The primary factor which has persuaded theater owners that air conditioning will prove a profitable asset has been the spectacular cooling of the house during the extremely hot weather of summer. This, too, has been the primary appeal to the public.

Though this is sufficient justification for the investment, air conditioning, as we shall define it, has much more to offer than the mere cooling during three or four sultry months.

Theater owners, even some of those who have wonderfully complete air conditioning systems within their houses, have been prone to think of and term the equipment a refrigeration system. They play this feature up to the public in frosted letters nicely arranged about pictures of polar bears and icebergs. Fine!—psychologically, but not without its unfavorable reactions. Furthermore this type of advertising was used long before any theater had a system capable of cooling and reducing the humidity.

Air conditioning as provided in the theater is not simply a refrigeration system. The refrigeration machine is not used to make

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ce according to the popular conception. The refrigeration machine has little more to do with the system as a whole than the boiler by which the theater is supplied with heat in the winter. Nor is it more important than the indispensable fan which is used to distribute the conditioned air.

It is important, therefore, that the owner should know that a complete and properly installed air conditioning system provides his house with the means of maintaining ideally comfortable and healthful conditions *every day in the year*. Furthermore he has something to offer his patrons which cannot be approached by a theater not so equipped.

People are learning by *feeling for themselves* the comfort which is offered in an air conditioned theater in contrast to many of our old buildings, particularly the legitimate houses, which are almost invariably stuffy and overheated even on the coldest winter day. We believe that from this point of view the owners who have invested in air conditioning systems are overlooking a field of exploitation. The average person is conscious of comfort principally by contrast. That is why it has been easy to attract the public from the hot streets to the pleasant atmosphere of a properly cooled theater. At times when outdoor conditions do not bring this contrast boldly to the attention of the patron the only comparison we have is to bring to his mind the fact that he *is* comfortable in comparison to some experience which he has had in a stuffy overheated audience. In other words, the human mind is conscious of discomfort but it is necessary for the showman to create a consciousness of comfort by word or picture. For instance, it would be advisable within an air conditioned theater to run a trailer occasionally saying, "Isn't the atmosphere comfortable in here? The air within this theater is scientifically conditioned for your health and comfort." If the claim is true, and there are theaters in which this is so, the audience has thereby been led into a consciousness of comfort and will remember it.

We choose, therefore, to define and describe as briefly as possible to motion picture engineers what air conditioning is and what it may be expected to accomplish.

Properties of the Atmosphere

The air which we breathe is the source of life-giving oxygen but, aside from this, air serves a very important purpose as a carrier of heat and moisture to or away from our bodies and our lungs.

The temperature of air is indicated for us by the use of the ordinary thermometer. But, the temperature of the atmosphere is not a true indicator of its heat content. The heat is also dependent upon humidity, for heat is required to evaporate water and such heat is retained in the atmosphere as *latent heat of evaporation*. So, when we are considering air as a medium through which we may warm or cool the human body, consideration must be given to its humidity as well as to its temperature.

Humidity

The moisture which is associated with atmosphere in the form gaseous vapor is known as the *humidity* of the atmosphere. The weight of moisture associated with a given volume or a given weight of air is known as the *absolute humidity*.

Air is said to be saturated with moisture when the space occupied jointly by air and water vapor contains the maximum amount of water vapor possible to remain in the vapor form at the existing temperature. The higher the temperature the greater is the quantity of water which can exist in a given space in vapor form. For instance, saturated air at a temperature of 70°F. contains 8 grains of moisture per cubic foot (1 grain = 1/7000 lb.) while air saturated at 85°F. contains nearly 13 grains of moisture per cubic foot.

Relative Humidity

When the atmosphere contains less moisture than is necessary for saturation at a given temperature, the moisture content is usually expressed in terms of *relative humidity*; that is, as a ratio of the weight of vapor actually present to that which might exist if the air were saturated at the given temperature. For example, assume that we have air at 70°F. containing 4 grains of moisture per cubic foot. By reference to tabulated data, we find that air could contain 8 grains of moisture per cubic foot if saturated at 70°F. It is said, therefore, that at this condition the air has a relative humidity of 50 per cent.

Dew Point and Dehumidification

If this air at a temperature of 70°F., containing 4 grains of moisture per cubic foot, were by some means cooled down to 50°F. we should find that the 4 grains of moisture would then be sufficient to produce saturation. In this case, the temperature of 50°F. is known as the *dew-point* of the air. In other words, dew begins to

form or the moisture begins to condense at this point. If we should cool below 50°F., *dehumidification* or the reduction in moisture content would be accomplished. Dehumidification is a subject of interest and one which will be discussed more fully in another part of this paper.

Temperature, Humidity and Heat Measurements

The most simple and reliable instrument for the determination of the temperature, the absolute and relative humidity, the dew-point

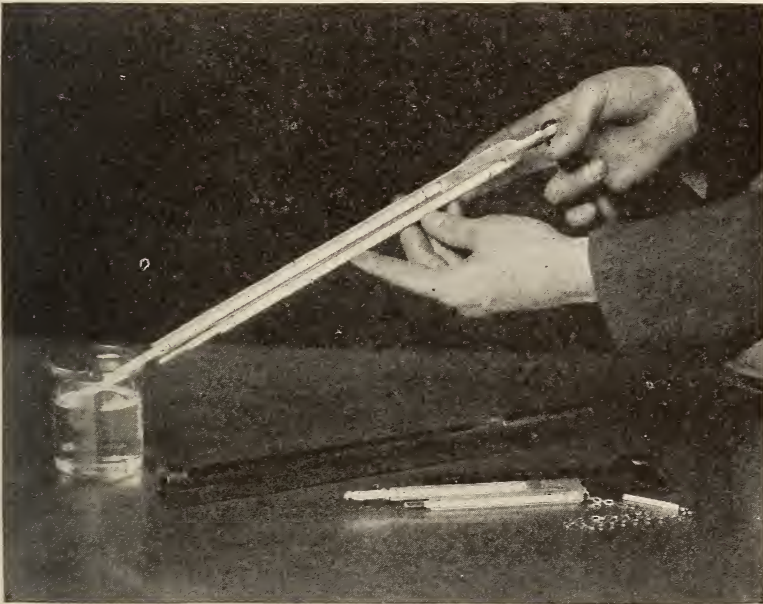


FIG. 1. Two convenient forms of the Sling Psychrometer. The larger instrument has 12-inch thermometers graduated in one degree divisions. The smaller instrument, lying on the table, has a smaller temperature range and less open graduations but is a convenient pocket type.

and the heat content of the atmosphere is the *sling psychrometer*, shown in Fig. 1. This instrument is comprised of two similar mercury thermometers mounted on a metal strip attached to a swivel handle or chain to permit whirling. The bulb of one of the thermometers is covered with a fabric sheath and is to be thoroughly wet with water during observations. This is known as the wet bulb. The companion thermometer is called the dry bulb.

In an unsaturated atmosphere the wet bulb thermometer is cooled by evaporation. The amount of cooling is dependent upon the temperature and initial moisture content of the air to which it is exposed. The number of degrees which the wet bulb is cooled below the temperature indicated by the dry bulb is known as the *wet bulb depression*.

A convenient set of curves has been constructed, in the Psychrometric Chart, Fig. 2, to which the simultaneous wet and dry bulb

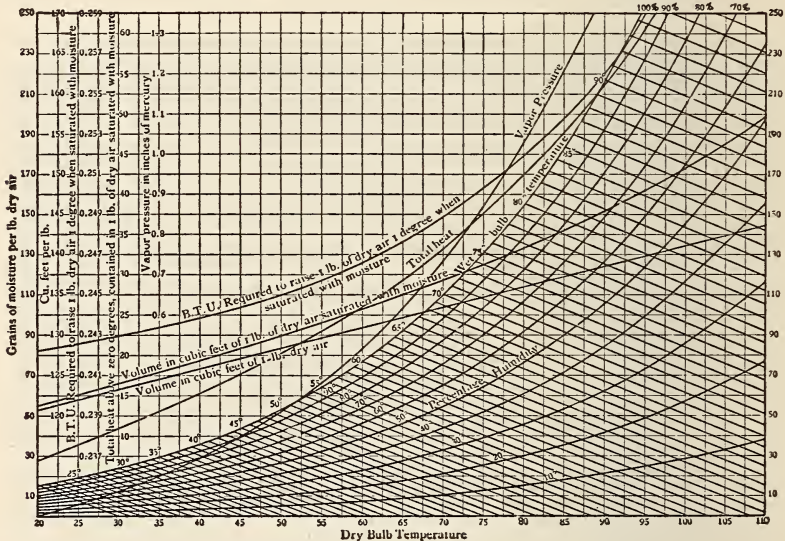


FIG. 2. Psychrometric Chart.

observations are referred for the determination of relative humidity, dew-point, etc.

It would be too involved to present here a discussion of the theory of the wet and dry bulb thermometer or the charts. However, the theory and practice are both simple and very lucid papers and instructions are available for those who wish to undertake such a study. It is well, however, to point out here that the wet bulb temperature when related to the ordinary dry bulb temperature of the air is the most important indicator of the condition of comfort.

The Comfort Zone

Human comfort or discomfort depend entirely on the relation between the rate of heat production within the body and the rate at

which heat is removed. The mechanism of the human body is marvelous in the fact that within a very wide range of atmospheric conditions our body temperature is maintained at a constant point. The body loses heat to the atmosphere and to surrounding objects by radiation and convection. The rate of heat loss depends upon the difference between the temperature of the body and the surrounding air and also upon the motion of the air or the rate at which the zone of air immediately surrounding the body is replaced. Heat is also lost by evaporation of moisture from the surface of the body, the rate depending upon the relative humidity of the air and upon the motion of the air. This surface evaporation is a very important element in its effect upon comfort. It is through the opening and closing of the pores and the consequent stimulation or decrease of perspiration that our body temperature is controlled so accurately. Further heat is lost in warming up the air inhaled and in saturating it with moisture.

If the condition of the atmosphere is such that heat is not carried away by air movement or by evaporation at the same rate at which it is generated, we experience discomfort and under extreme conditions, health is endangered. On the other hand if the air is so dry, so cold, or moving so rapidly that it tends to carry heat away from the body faster than it is being generated, we experience a chilling effect.

The American Society of Heating and Ventilating Engineers, at the laboratory of the Bureau of Mines at Pittsburgh, has conducted a long series of experiments which has laid down for us the combinations of temperature, humidity and air movement which are conducive to the maximum state of physical comfort. For example, it has been shown that the average person will experience the same sensations of warmth under the following combinations of temperature and humidity at a given rate of air motion:

<i>Dry Bulb Temp.</i>	<i>Relative Humidity</i>
80°F.	12 per cent
75°	38 " "
70°	73 " "
67°	100 " "

All of these combinations of conditions are classified arbitrarily as being of the same *effective temperature*. That is to say, they create the same sensation. In this set of examples, the effective temperature is 67°F.

Effective temperatures have been superimposed or plotted upon a Psychrometric Chart such as is shown in Fig. 3. Outlined upon this chart is an area known as the comfort zone. It has been found that combinations of conditions of temperature and humidity lying outside of this zone are not comfortable to the average person. The line of maximum comfort, it will be noted, is the 64° effective temperature line. Some authorities are inclined to place this line somewhat higher in

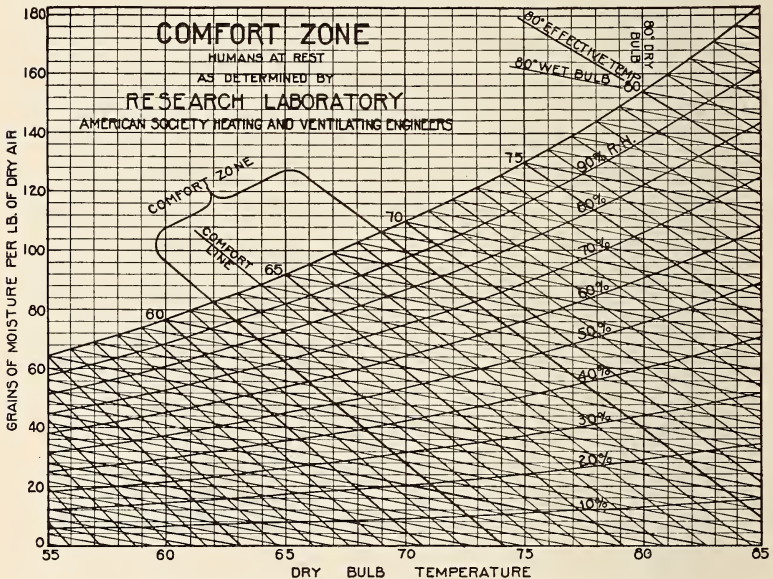


FIG. 3. The Comfort Chart for Humans at Rest.

the scale. The particular comfort chart shown here is for comparatively still air. If the velocity of the air were increased the result would be to tip the effective temperature lines more toward the horizontal. It would then be found that the same conditions of comfort would be produced for a given dry bulb temperature with a higher relative humidity than that shown on this chart.

The effect of air motion in producing cooling increases with the velocity at all temperatures below 98.6°F. , the normal body temperature. Above this point increased velocity naturally tends to convey more heat to the body and to increase the effective temperature.

The value of such data as this cannot be over-estimated for they have given us very definite limits within which to operate in the creation and control of a comfortable atmosphere.

Those who have had experience in observing the conditions of comfort within theaters or public buildings have found definite verification for this range of comfort temperatures. It is an interesting fact that whenever the limits of the comfort zone are exceeded individuals in the audience begin to fan themselves or give other evidence of discomfort. A further interesting fact is that the familiar and unpleasant odors typical of a crowded room develop immediately when the upper range of the comfort zone is exceeded.

Air Conditioning

Air conditioning is the science of creating and automatically controlling stipulated conditions of temperature humidity and air movement within buildings, regardless of outdoor conditions.

For more than 25 years engineers specializing in this field of work have been developing equipment and devising methods for controlling air conditions and the effect upon materials and manufacturing processes in a large variety of industries. So the science is by no means new though its application in the theater and public building field dates back scarcely a half dozen years.

An Engineering Problem in the Theater

Though there were many special problems to be solved in applying air conditioning to the theater the principles and much of the equipment had undergone long trial and development within the industries.

It is perhaps well to say here that under the term air conditioning we are not including simple ventilation systems which are designed solely to change the air within the building. These are not without merit but they constitute only a portion of an air conditioning system.

Given the air conditioning equipment and methods developed in the numerous industrial applications and given the limits of comfort as stipulated by experience and the researches which we have mentioned; the application of air conditioning within the theater has been one of engineering adaptation.

The very nature of the usual theater structure has, however, offered enough unique and difficult problems to demand the utmost in engineering background and skill. Here in a single enclosure are

to be gathered anywhere from a few hundred to six or seven thousand people for a period of 12 hours per day. Myriads of lights are to give off heat. The ceiling in some houses is full six stories above the orchestra. An immense cantilever balcony extends half way over the orchestra to obstruct air circulation. A vast lobby and foyer frequently packed with standing patrons offer an added problem.

The chief consideration for the air conditioning engineer is the manner in which a sufficient quantity of properly conditioned air may be supplied to and uniformly distributed within such an enclosure.

An Outline of Theater Air Conditioning Practice

Let us outline the ideal conditions which should be maintained within a theater and follow the process of their accomplishment.

1. The air should be relatively clean, washed or filtered to protect the health of patrons and to preserve the beauty of the decorations and draperies.

2. During the summer a temperature of approximately 75°F. and a relative humidity of 55 per cent is in most cases comfortable, though there is a tendency now to carry a slightly higher temperature and a correspondingly lower relative humidity. During the winter a temperature of approximately 70°F. with a relative humidity of from 35 to 50 per cent is found practicable and comfortable.

3. The proper quantity of conditioned air to be supplied to the theater is generally conceded to be about 30 cubic feet per minute per person. This is not based upon the quantity of air which one breathes in a minute. The average person inhales little more than a cubic foot of air per minute. The quantity of air is based rather upon the heat dissipation of the average individual which is sufficient in one minute to raise the temperature of 30 cubic feet of air approximately 9°F.

4. Finally, this quantity of air must be carried to and distributed uniformly throughout every portion of the building. Since the air is cooled, the greatest care must be used in regulating the velocity and the direction at which it is delivered in order to avoid draughts. In other words, reference must be made to the comfort chart and the velocity of air delivered carefully adjusted to establish a comfortable combination with the existing temperature and humidity.

5. A certain quantity of fresh outdoor air should always be a part of the air delivered to the house. The practice in this regard

varies rather widely. Some cities have ordinances which require that all of the air delivered to the theater be fresh outdoor air and forbid recirculation of any portion of the air within the building. Such a

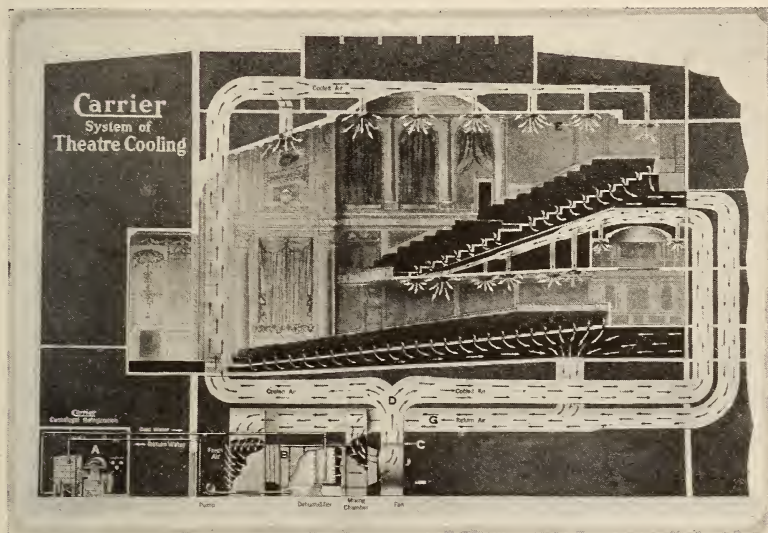


FIG. 4

A. The Carrier Centrifugal Refrigeration unit which cools the water for the spray chamber.

B. The spray chamber or dehumidifier where the air is dehumidified, cooled and cleansed.

C. The centrifugal fan which draws the air through the spray chamber and passes it through metal ducts to the theatre.

D. The large metal ducts through which conditioned air is passed to the ceilings of the theater.

E. The downward diffusion outlets through which the air is diffused over the audience, reaching the Breathing Zone first with complete absence of draughts.

F. The chambers beneath the balcony and orchestra seats into which the air is drawn from the theater.

G. The large metal ducts through which the used air passes back to the spray chamber to be rewashd, cooled, dehumidified and mixed with fresh air.

requirement is absurd and would subject the owner to a prohibitive expense either to heat or to cool his theater. Air conditioning engineers and numbers of health authorities have pretty generally agreed that a constant minimum dilution of 25 per cent of fresh outdoor air or approximately 8 cu. ft. per minute is ample from every point of view.

We have outlined five general problems which are to be solved in establishing ideal air conditions within the theater.

Consider now, a theater completely equipped with a typical air conditioning and refrigeration system. The cross section of such a building and its air conditioning equipment are shown in Fig. 4. Assume that we have an outdoor temperature of 85°F. and wet

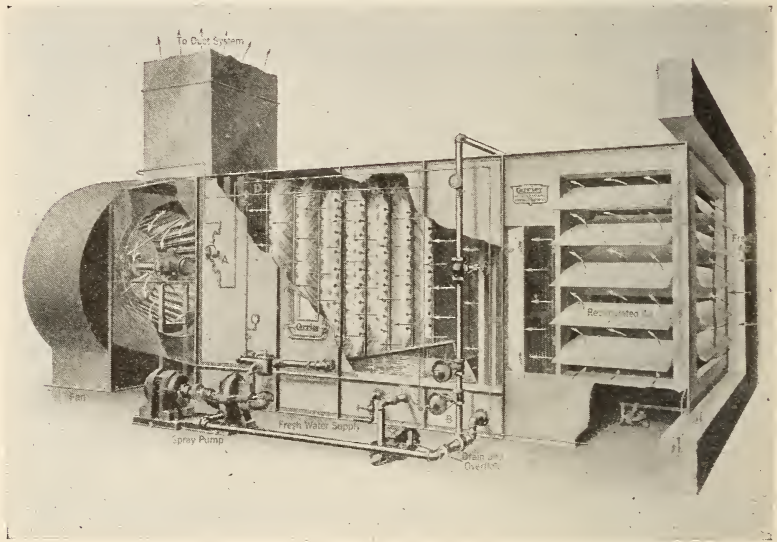


FIG. 5. Humidifier or Dehumidifier showing automatic dampers for the admission of fresh and recirculated air on the right, the spray chamber; the pump; automatic control instruments and valves and on the left, the fan which discharges the conditioned air to the duct system leading to the various portions of the building.

During the summer, the water is cooled by refrigeration and in turn cools the air passing through the chamber. The cooling also causes the excessive moisture to be condensed.

During the winter, the same chamber serves to wash and purify the air and contrary to the summer practice *adds* the proper amount of humidity to the air for healthful comfort.

bulb temperature of 75°F. This is not an unusual summer day. Under these conditions the outdoor relative humidity is found on the Psychrometric Chart to be 63 per cent. The dew-point or condensation temperature of the outdoor air is about 71°F. We wish to establish, as outlined in No. 2 of the requirements given above, a temperature of 75°F. and a relative humidity of 55 per cent. We find from the Psychrometric Chart that this condition calls for a dew-

point of approximately 57°F. in the theater. We have not only to cool the air from 85° to 75° but we have to *dehumidify*; that is, to condense sufficient water out of the air so that the dew-point is lowered from 71° to 57°F. Observe then how this is done.

We have as a part of the air conditioning equipment a spray chamber such as shown in Fig. 5 within which hundreds of small nozzles are atomizing perfect clouds of water. During summer operation the water supplied to this chamber is cooled by refrigeration to a temperature of about 45°F. By means of the large centrifugal fan, air is drawn through this chamber in intimate contact with the water spray. Here it is completely washed, meeting requirement No. 1 stipulated above; here also it is cooled to a temperature of about 50°F. The air has given up its heat to the water and the water temperature has risen about 5°. Observe also, that in cooling the air to this extent we have gone below the initial dew-point of the outside air. Therefore, water vapor must have been condensed out of the air. In other words, we have reduced the dew-point of the entering air from 71° to 50°F.

From this chamber the air is drawn into the fan. It would not be desirable to admit air at 50°F., saturated as it is, upon leaving the spray chamber. Some economical means must be adopted for raising the temperature of the air and incidentally for reducing its relative humidity. One very economical method of doing this is a patented scheme of recirculation. Some warm air is drawn from the theater and intermixed with the cold saturated air at the intake of the fan. The mixture has a temperature ranging from 62° to 65°F. and the dew-point of this mixture has been slightly increased by the vapor carried in the warm recirculated air. The fan then delivers the air through a metal duct system to outlets carefully located in the high ceiling of the theater, in the ceiling beneath the balcony and at other points throughout the building where cooling is required. The location and the design of the outlets has been a matter of careful investigation on the part of air conditioning engineers. The air delivered through these is not *blown* into the building but is delivered at adjusted velocities and is so directed that the result is one of diffusion, a blanket of air, passing downward over the audience.

The temperature of the air leaving the outlets ranges from 62° to 65°F. In mixing with the warmer air of the theater, gathering up heat which has been given off by the occupants, by lights and through

infiltration from out-of-doors, it reaches the breathing zone at our stipulated temperature of approximately 75°F.

After passing over the audience, a portion of the air is withdrawn through *mushroom* openings beneath the seats or through openings arranged at other low points. This air is drawn back to the spray chamber to be rewashed and re-cooled or a portion of it may be mixed with the stream of newly washed air, as previously explained.

Since an adjusted quantity of fresh outdoor air is at all times being drawn into the air conditioning system, a like quantity is being discharged from the theater. In a properly balanced system the overflow occurs outward through the lobbies and exits. Thus the air within the building has a very slight outward pressure. The old bothersome inward draughts are eliminated and the commonly used glass screen to protect the audience at the rear of the orchestra seats is no longer needed.

This system of air circulation is known as the downward diffusion system and is pretty generally conceded by air conditioning engineers to be far superior to the former practice of admitting conditioned air at the floor line.

Automatic instruments located in the supply and return airducts are subjected to the incoming and outgoing conditions of the air and react upon systems of dampers and valves to produce the proper temperature and humidity at the breathing zone. The automatic instruments which have been developed for this purpose are positive and extremely accurate. Once properly installed they are almost fool-proof and require practically no attention.

Refrigeration

In describing the spray chamber within which the air is cooled and dehumidified we mentioned that refrigeration is necessary for reducing the temperature of the water to about 40° or 45°F. Most any form of refrigeration machine can be used to cool water. There are requirements, however, within a building, such as a theater, which narrow the selection of refrigeration equipment down to two types. The refrigerating medium must, in the first place, offer no hazards to congregated people. This immediately bars the use of the familiar refrigerants, ammonia, sulphur dioxide and such gases as are offensive or dangerous.

The second requirement is compactness, because most theaters are limited in available space for equipment and the property upon

which they are constructed is usually valuable. Again, compactness will offer a decided saving if excavation is required.

The two refrigeration systems which have found successful adaptation in the theater have been the reciprocating machines using carbon dioxide as a refrigerant and the more recent development Carrier Centrifugal Refrigeration, using as a refrigerant, "Carrene"

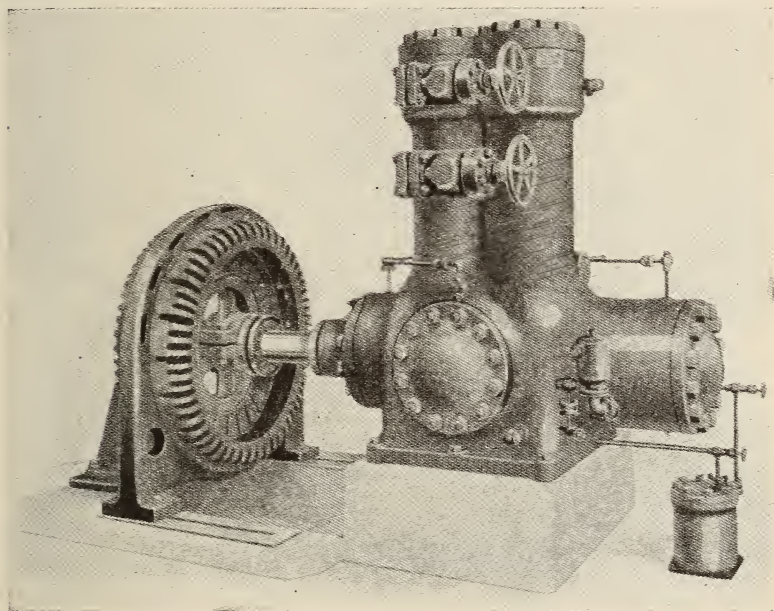


FIG. 6. A modern type York carbon dioxide refrigeration compressor. The piping separators and other auxiliary equipment leading to the expansion and condenser coils are not shown. The banks of pipe coils in which the compressed is condensed and the expansion coil where cooling is produced are usually located at a distance from the compressor.

(dichloromethane $C H_2 Cl_2$), one of a group of stable liquid chemicals which have been found suitable for centrifugal compression.

The fundamental theory of all refrigeration systems is the same. Expansion or evaporation or boiling are processes which absorb heat in their performance or, looking at it another way, which produce cooling.

Carbon Dioxide

Carbon dioxide is a gas at all ordinary atmospheric temperatures and pressures. In the cycle of refrigeration, its pressure is increased

to 1,000 lbs. or above by a reciprocating compressor; that is, a compressor which performs its work by the action of a piston within a cylinder, illustrated in Fig. 6. After compression to this degree, the very dense gas is caused to liquefy or condense within a double pipe system through which water from the city mains or from a cooling tower is circulated. The condensed carbon dioxide or dense gas then passes from the condenser to expansion coils which are surrounded by the water to be cooled for the spray chamber. Within these coils

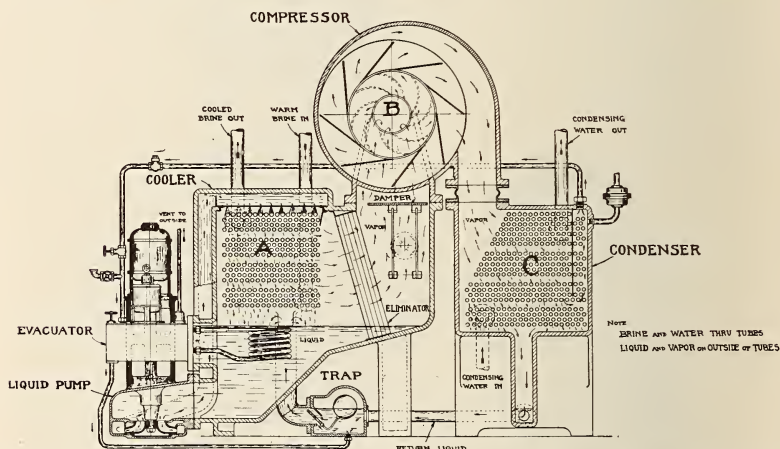


FIG. 7. Diagrammatic arrangement of the Carrier Centrifugal Refrigeration Unit showing assembly of the cooler, compressor and condenser and the complete cycle of refrigeration.

the expansion or boiling of the carbon dioxide takes place with the consequent absorption of the heat from the water which it is intended to cool.

Centrifugal Refrigeration and the New Refrigerant

Carrene, the new refrigerant used in centrifugal refrigeration, is liquid at all normal atmospheric temperatures and pressures. It can be carried in open containers. The cycle through which this refrigerant is carried to produce cooling is as follows.

Within a vacuum-tight compartment known as the evaporator the liquid refrigerant is allowed to flow over a large number of bronze tubes. (See (A), Figs. 7 and 8.) Through these tubes the water to be cooled for the spray chamber is circulated. By means of a centrifugal compressor, which in many respects is similar to an ordinary

centrifugal water pump, a vacuum of approximately 25 inches of mercury is maintained within this cooling compartment. (See (B), Figs. 7 and 8.) At this reduced pressure the boiling point of the liquid refrigerant is largely reduced. This vigorous boiling occurs on the outside of the tubes and heat is absorbed from the water which is being circulated to and from the spray chamber. The vapor which

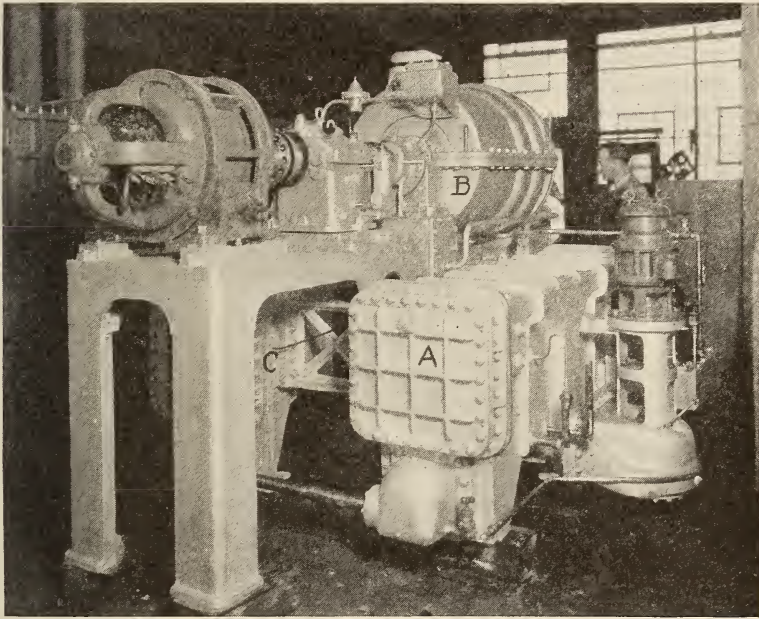


FIG. 8. A complete Carrier Centrifugal Refrigeration Unit. (A) The evaporator or cooler; (B) The Centrifugal compressor; (C) The condenser. A unit this size would be used to cool and dehumidify a 1000 seat theater.

results from this boiling is drawn into the centrifugal compressor. Through the several stages of the compressor the pressure of the vapor is raised to such a point that it is possible to cause condensation of the vapor by water at such ordinary temperatures as are available within city water supplies or from cooling towers. This condensation is produced in a compartment within which bronze tubes are arranged in exactly the same manner that we have described for the cooling compartment. (See (C), Figs. 7 and 8.) The refrigerant having been reconverted to a liquid then flows back to the cooling compartment to be re-used, thus completing the very simple cycle.

Centrifugal Refrigeration and the liquid refrigerant are well adapted to the problems involved in the application of air conditioning. The harmless nature of the refrigerant, the extreme compactness of the machine and the fact that the refrigerant does not leave the closed circuit within the machine itself are the novel features which have favored its adoption in many theaters.

The Refrigeration Season

A theater having a complete air conditioning system including refrigeration should operate the refrigeration machine at all times when the outdoor wet bulb temperature exceeds 55°F. The wet bulb temperature is the temperature which would be assumed by the water in the spray chamber if recirculated without means of cooling.

During a period of about four months of each year, nearly every city in the United States experiences a predominating number of days at which the wet bulb temperature exceeds 55°F.

Air Conditioning in Winter

We now turn to a problem of conditioning the air on a typical winter day. Assume that the outdoor temperature is 32°F. and that the outdoor air is saturated with moisture, as it frequently is at this temperature, so the dew-point of the air brought into the spray chamber from out of doors is likewise 32°F. We have stipulated in our requirements for comfort in the theater a winter condition of 70°F. and a relative humidity of from 35 to 40 per cent. From the Psychrometric Chart, we find that this condition establishes a dew-point of 42°F. In other words, our requirement within the spray chamber during the winter is to *humidify* the air, that is, to add moisture rather than to dehumidify. Under the conditions assumed, we can accomplish this by heating the fresh air taken in to a temperature of 50°F., which raises the wet bulb temperature of the incoming air to 42°F. and it is at this point that the air will become saturated within the spray chamber.

As in the summer time, a controlled amount of re-circulated warm air is mixed with the air which passes through the spray chamber so that the condition of the air delivered is approximately 70°F. and the relative humidity is approximately 35 per cent.

It is interesting to note that under all conditions during the winter when the theater is well filled, the air conditioning problem is still one of cooling rather than of heating. The air delivered from the

diffuser outlets is, as during the summer, at a temperature of about 62°F. and in passing down over the audience collects the necessary heat to raise it to a temperature in the neighborhood of 70°F.

In the theater having complete air conditioning equipment there is practically no use for any direct radiation heaters. Occasionally a bank of direct radiators is placed in the vestibule which opens directly to the outdoor atmosphere. The elimination of direct radiation within the building has many advantages. It obviates the local overheating of certain sections of the theater where steam pipes or radiators might be located. Automatic control of the heaters located within the ducts through which the air is carried acts quickly and accurately. An interesting analysis of the fuel saving accomplishment by air conditioning during the winter could be made if we had space here to do it. It is enough to say that little or no steam is required or used in heating the building, except in the warming up before the crowd is admitted. Once the theater is occupied the heat given off by the audience is sufficient to overheat the house and, as we have said, there is a cooling problem to be solved.

The Cost of Air Conditioning

The theater owner is naturally interested in the cost or the economic side of complete air conditioning equipment. This is logical and the only basis upon which he can consider it. It is possible here to give only some very general figures. To date, most of the air conditioning systems in theaters have required an initial expenditure approximating \$32.00 per seat. This includes a complete conditioning system, the refrigeration machine and all expense to which the owner is placed in the alteration of an old building or in adapting a new structure to the equipment. Frequently the figure has been as much as 25 per cent below this amount.

In certain typical installations which we have investigated, the cost of operation per day per seat throughout the year averages between 3 and 3½ cents. This includes depreciation, the engineer's salary, power, steam, water, interest on the investment and all incidentals. Naturally, the cost of operation during the winter is much less than in the summer.

On the assumption that each seat is occupied at least twice a day, and this is below the reasonable expectation of the firstclass house, the cost per ticket to make a patron comfortable is slightly over 1½ cents.

While considering this cost, the owner should also consider that many items which are included therein are those which would have to be borne under any circumstances. The system replaces the ordinary heating, air washing and fan system that might be installed and this is also true in the employment of an attendant or attendants. Careful estimates of the costs and maintenance of the ordinary air washing, heating and ventilating system show a cost of approximately 2 cents per day per seat. The expected cost per patron is 1 cent.

Thus the difference in cost of complete air conditioning and the usual air washing, heating and ventilating amounts to something like 1/2 cent per expected patron.

The difference per day per 1000 seats is approximately \$15.00. A daily sale of 43 additional tickets absorbs this excess.

Experience has shown in theaters having complete air conditioning that the increase in summer patronage makes this expense extremely insignificant. Official box office reports show in not a few instances an increase of from 50 to 100 per cent in average summer receipts accredited primarily to the air conditioning system. Furthermore, these same houses have shown a notable increase in receipts during the intermediate and winter seasons.

This analysis and comparison must not be understood as a sale argument. It is offered with complete fairness and with the sole object of indicating to the owner the factors which must be dealt with in considering the undeniable fact that comfort of patrons is an asset.

Air Conditioning in the Film Laboratory

Here we approach an important application of the science of air conditioning which far antedated atmospheric control in the theater.

We have pointed out in the first paragraphs of this paper that air conditioning found its inception in the necessity for artificially establishing and controlling suitable atmospheric conditions for the efficient and successful accomplishment of many industrial processes.

From the beginning of the development of the photographic film art, it has been necessary to use many precautions in protecting the delicate surface of the film as it passes through the many operations prior to, and after, exposure.

It has always been necessary, for instance, to protect the film from a dusty atmosphere which would cause particles to adhere to the adhesive gelatine surface while the film is in a wet state. The film laboratories have long since adopted numerous measures for

filtering or cleansing the air admitted to their process rooms and many laboratories have sought rural locations where the outdoor atmosphere is comparatively free from dust.

As the art of film making has advanced and as the demand for quantity production has increased together with the necessity of meeting production schedules, the need for creating and controlling suitable atmospheric conditions has become a decidedly more important factor.

The following are points in the application of air conditioning toward the improvement in the production of motion picture film.

1. Wet coated film must at all times be protected from an atmosphere containing solid particles of any form. This imposes the requirement for the complete and efficient filtration or washing of all air admitted to developing, drying or printing departments.

2. The atmosphere to which a dried film is exposed for any considerable period should have sufficient humidity to maintain the pliability of the film. This is to avoid brittleness and the chance of breaking when the film is subjected to handling or is passed through printing or projection machines.

3. Films, negative and positive, which are to be run through a printing machine, should have previously been exposed to a humid atmosphere for a determinable period, and the printing operation should be conducted in an atmosphere of sufficient humidity to prevent the generation of static electricity with its consequent marking of the sensitized surface.*

4. Film drying rooms or cabinets should be provided with equipment to establish and maintain determinable conditions of temperature and humidity. Through controlled rates of drying film curling and buckling can be largely eliminated and the danger of the distortion of the gelatine surface as a result of excessive conditions of temperature and humidity may be prevented.

5. Means should be available to automatically control the temperature of developing and fixing solutions and wash water. This does not come primarily under the heading of air conditioning but in some of the modern equipped laboratories such a system operates in conjunction with the air conditioning system. It is also desirable to maintain controlled conditions of temperature and humidity within the developing rooms.

* See "Static Markings on Motion Picture Film", by J. I. Crabtree and C. E. Ives.—*TRANS. S. M. P. E.* 21, 1925, 67.

In outlining these desirable possibilities, we have given thought to the fact that all laboratories do not operate on a sufficiently large scale to justify all of the elaborations of equipment outlined. We choose, therefore, to suggest in their order of importance the measures which a laboratory might adopt for atmospheric control.

Air Filtration

The first requirement is, of course, to deliver air to the laboratory completely free from dust or solid matter. The most simple and

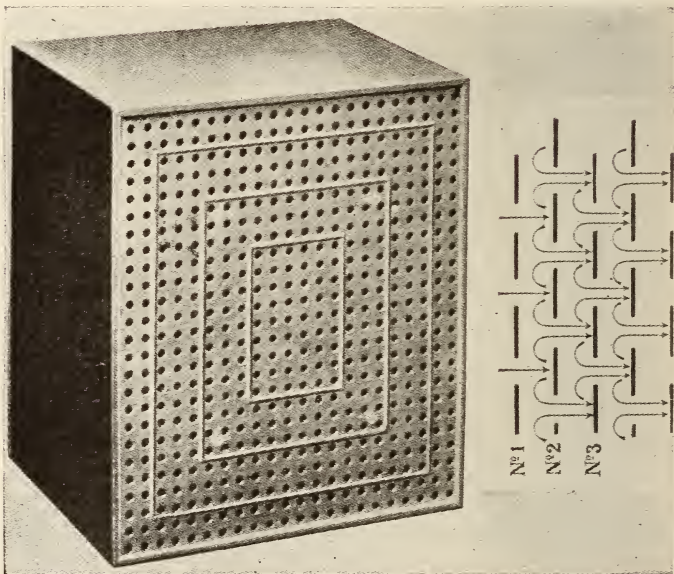


FIG. 9-A. The Sectional Air Filter Dry Impingement Type. Air path is shown on right. Each perforated plate is covered with a dry fibrous material to which the dust adheres upon impingement.

inexpensive means of accomplishing this is to draw the air through one of the several types of commercial air filters and thence to deliver the air to the room or to the drying cabinet by means of a fan and duct system, the selection and design of which would, of course, depend upon individual requirements.

There are five general types of commercial air filters, illustrations and descriptive captions of which are shown in Fig. 9. We cannot attempt here to discuss the relative merits of these various devices.

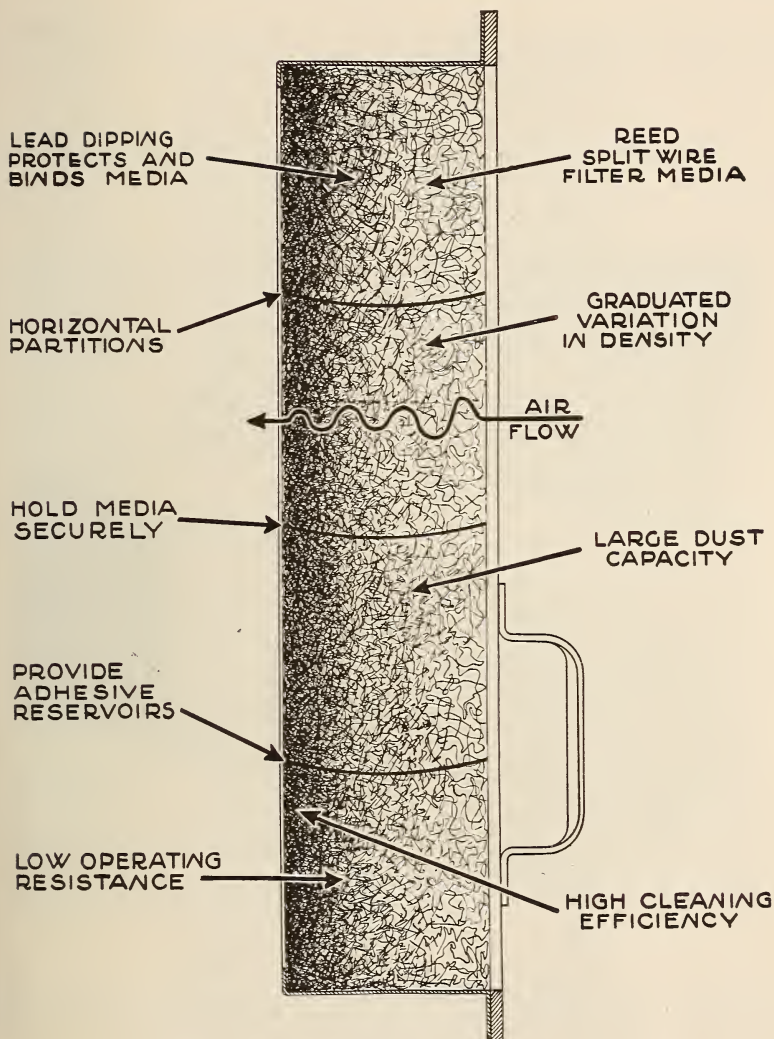


Fig. 9-B

The Viscous Coated Air Filter sectional Type. Filtration is effected by dipping the unit in a viscous fluid. Periodic removal of the sections is required for cleaning and recoating.

We may say, however, that we believe any one of these types will effectively clean the air for commercial work and that the preference in selection may depend first upon cost, upon comparative efficiency

or air resistance, upon ease of cleaning and the necessary frequency of cleaning or replacement.

The Air Washer

The alternate selection which might be made for simple dust elimination and one which, though more expensive, offers some

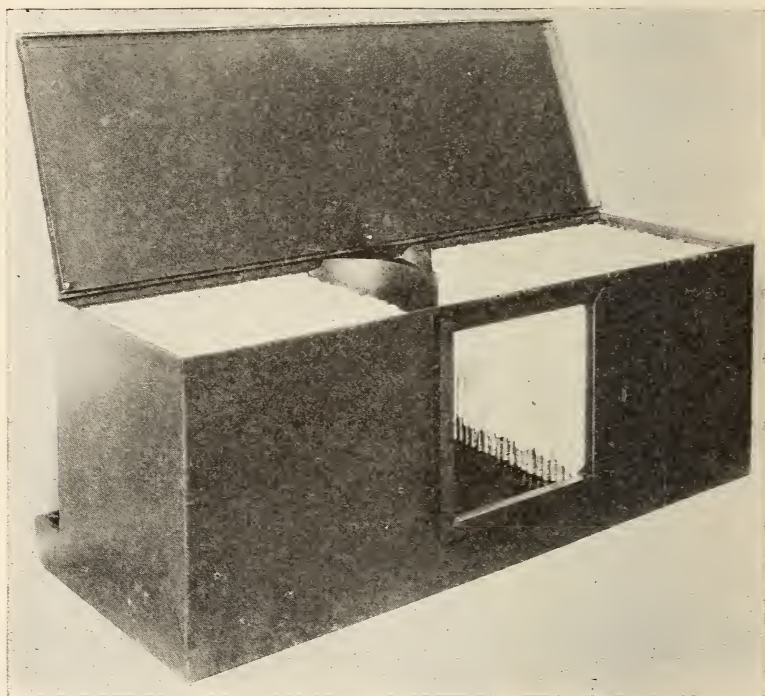


FIG. 9-C

The Multi-Pocket Cloth Air Filter. Dry Type. Each cloth envelope is an independent unit stretched over a frame. The lower edge of cloth and frame are immersed in oil which serves as a seal. Air passes through the entire outer surface and out at the slot in the bottom.

advantages in its possibility of partial humidity and temperature control, is the air washer or water veil system of air cleansing.

Such a system is comprised of a metal chamber within which water is minutely atomized through nozzles arranged in vertical pipes as illustrated in Fig. 10. An air washer will produce some reduction in temperature within the laboratory during the summer and has

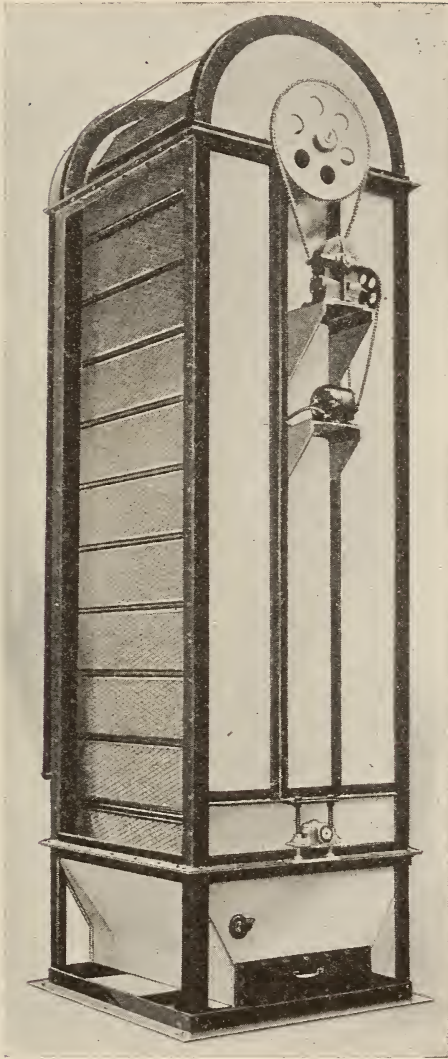


FIG. 9-D

The Viscous Coated Air Filter Continuous, Self Cleaning Type. The filter elements are periodically rotated by the motor carrying the sections into the bath of viscous fluid in the base.

the advantage of relieving the extremely arid condition which is created within artificially heated rooms during the winter. The

effectiveness in dust elimination compares favorably with non-humidifying air filters.

Humidifier

The humidifier is similar in almost every respect to the air washer except that it is designed to use a greater quantity of water and is

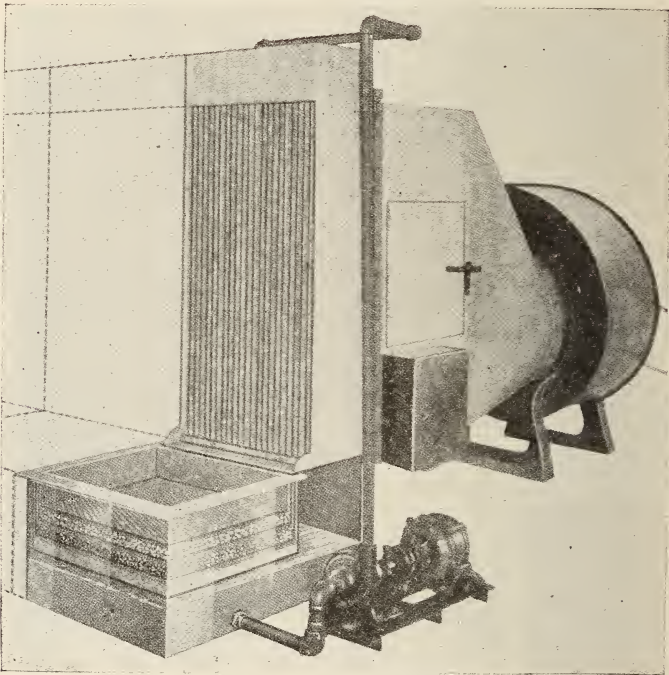


FIG. 9-E

The Viscous Coated Air Filter Self Cleaning, Stationary Element Type. The filter element is composed of vertical tubes having a stream-line section. Viscous fluid is periodically pumped up from tank at bottom and flooded over elements.

equipped with instruments to effectively establish and control temperature and humidity in the rooms to which the air is being supplied.

This equipment is particularly desirable since it meets in nearly all respects the requirements laid down in Nos. 1 and 2 of our enumerated advantages of air conditioning as given above. Such equipment can be adjusted to maintain the desirable moisture content in the

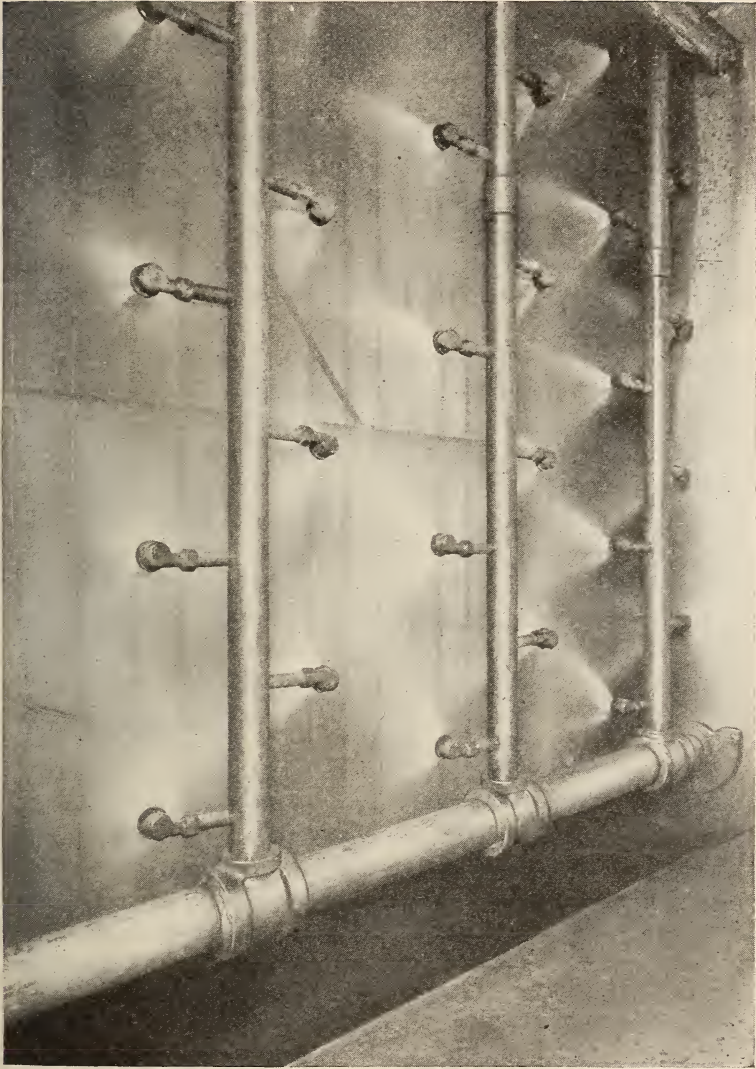


FIG. 10

film stock and to maintain the proper condition of humidity in the printing room to eliminate static marking.

The greatest demand for such control comes, as previously intimated, during the winter season. The outdoor air during the

winter carries very little moisture, and upon being artificially heated to indoor temperatures, a condition of exceedingly low relative humidity is established, which is highly conducive to static production.

It may be implied that there are periods during the humid summer season when a humidifier will not be required except as an air cleanser. This is so and it is not infrequent for laboratories to have in their equipment a combination of air filters and a humidifier. This permits the shutting off of the water spray when humidification is not required, the air filters serving to cleanse the air.

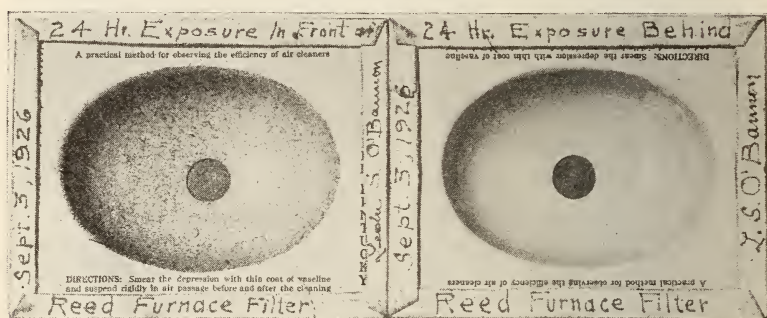


FIG. 11. A Simple Test for Effectiveness of Air Filtration. The surface of the porcelain plaque is smeared with a thin coat of vaseline and exposed to air stream.

Complete Temperature and Humidity Control

We come finally to the most elaborate equipment for air conditioning with which a laboratory could be provided. Several of the larger laboratories have such equipment, others are having such installations made. We cannot do better than to describe here the features of an installation that is now in process at the laboratories of the Attica Film Corporation in New York City.

Object of Air Conditioning Equipment

These laboratories are to be devoted primarily to the production of news films. It is, therefore, necessary to provide means of turning out finished film in good condition in the shortest possible period. The plans for applying conditioned air in this laboratory include the automatic control of temperature and humidity in four "Duplex"

drying cabinets, one large drum-drying room, two printing rooms and the wet end of the machine developing room. The air conditions to be maintained in these various departments are subsequently specified.

Since refrigeration is to be used for the cooling of the air in these rooms during certain seasons, the same refrigeration unit will be utilized to automatically cool and control the temperature of developing solutions.

Provision is also being made to automatically warm the developing solutions to a fixed temperature during the winter.

Apparatus

The air conditioning and drying equipment which will go into this laboratory consists of two water spray chambers which are to serve according to the season, either to cool and dehumidify the air or to warm and humidify the air supplied to the various departments.

Two fabric envelope type air filters are being installed on the discharge side of each spray chamber. These are to serve as a final assurance against dust and will permit, on occasion, the operation of the fans without the use of the water spray.

A Carrier Centrifugal Refrigeration Unit is provided for the cooling of the water supplied to the spray chambers in order to produce air cooling and dehumidification during the summer. This unit will also serve to cool the developing solutions.

There are to be four "Duplex" cabinet drying machines, each of which is equipped with an individual fan, heater and temperature and humidity control instruments.

Provision is made to supply by automatic control, fresh air to the drying cabinets from one of the spray chamber and filter systems.

The cabinets are thus completely protected from the admission of dusty air.

One large drum-drying room is supplied with automatically conditioned and filtered air delivered at high velocity through a row of patented ejector nozzles located near the ceiling. This provides for the rapid drying of films on several large drums in an open room.

Conditioned air is to be supplied under automatic temperature and humidity control to two small printing rooms.

Conditioned air is also being supplied to the wet end of the machine-developing room primarily for the purpose of ventilation and the health and comfort of the operators.

Specification of Results

The following guarantees have been made by the engineers who have designed and are installing this air conditioning equipment.

Drying

1. Air movement and humidity within the four "Duplex" drying cabinets are to be so controlled that drying can be successfully and satisfactorily accomplished at the rate of 30 feet per minute; this provides 240 feet of film per minute passing through the four cabinets.

2. The cabinets are to be so equipped that film may be dried at the rate of 50 feet per minute or a total of 400 feet per minute for the four cabinets. This is under the assumption that temperatures between 85 and 90°F. will be used and under these circumstances the operators assume responsibility for the quality of the film.

3. The air supply, heating equipment and automatic controls in the drum-drying room are to be such that 4200 feet of film can be dried on the drums in a period of 22 minutes at a temperature of 80°F.

4. The equipment in the drum-drying room will also provide the possibility of drying 4200 feet of film in a period of 10 minutes at temperatures between 85 and 90°F. Here again, however, the operators assume responsibility for the quality of the film.

Printing Rooms

1. The equipment is designed to maintain within the printing rooms temperatures not exceeding 75°F. when outside temperatures do not exceed 95°F. or an outdoor wet bulb temperature of 75°F.

2. It is planned that the equipment shall provide at all times within the printing rooms relative humidities between 65 and 70 per cent. Higher humidities than this may be maintained if desired.

3. The equipment provides means of automatically heating the printing rooms to a temperature of 70°F. in zero weather.

Temperature Control of Developing Solutions

1. The centrifugal refrigeration unit which is provided for cooling the water supplied to the spray chambers during the summer is also to be utilized to cool 100 gallons of developing solution per minute not less than 2° from the temperature at which it returns to the system from the developing tank.

2. Through automatic control, the developing solution is to be delivered from the cooling tank at a temperature of 68°F. with an allowable variation of 1°F.

3. Equipment is provided which is to automatically warm and maintain the developing solution at 68°F. during the winter.

Dust Removal

1. The equipment is guaranteed to remove all dust from the conditioned air circulated within the printing rooms, the drum-drying room and the drying cabinets.

Thus we have outlined the full equipment and application of air conditioning within the film laboratory. Beyond this is a matter of size and elaboration. For instance, conditioned storage rooms could be provided, in which a definite temperature and humidity could be maintained, for the purpose of retaining the pliability of the film.

No doubt, in the laboratory which we have described, a considerable stock of film will be kept on hand within the conditioned rooms so that all of the film handled will have a sufficient amount of moisture to be pliable. The films, sealed within metal boxes, in such a conditioned laboratory will go forth for use in a pliable condition.

DISCUSSION

MR. CRABTREE: What is the advantage of dichloro-ethylene over ammonia or carbon dioxide. Is it because if there is a break in the line it is not so dangerously poisonous?

MR. LINDSAY: Ammonia is out of the question in a theater. Carbon dioxide is harmless unless it diffuses into a house to such an extent as to produce suffocation. Dichloro-ethylene is a liquid, not a gas, at ordinary atmospheric temperatures and pressures. The boiling point depending on the purity of the liquid, runs from 120° to 180° F. Its density is about three and a half times that of air, which makes it adaptable to centrifugal refrigeration. It could be done with air, but would require a cumbersome equipment. We are limited as to size. The advantages are its safety, for if anything should break the machine, only liquid would run out. It is confined to a space about one-fifth that of any present refrigerating system.

MR. R. C. HUBBARD: Is the question of cleaning air by oil filters dealt with?

MR. LINDSAY: I have not gone extensively into that point; but as some editing of my paper has to be done this and other matters

as suggested here will be dealt with. We are using oil filters and oil seals in connection with air washers in laboratory work in order to doubly assure the removal of dust and particles of soot. There is nothing yet which will completely remove smoke, unless one uses electrostatic elimination.

MR. STEWART: In Mr. Faulkner's paper, which he read at the last spring meeting, he referred to the heat of the projection room. He correctly claimed that much of the dirt and dust of the theater, as seen in the rays of light from the projector, are attracted to the carbons of the arc, driven on to the film and cause scratching. In your ventilating could you not direct this dirt-laden air from the booth?

MR. LINDSAY: We are doing that. The projection room is conditioned, and there is a separate exhaust system going to each projection scheme. In all theaters that we have recently fitted out the heat is carried away from the lamp and conditioned air supplied to the machine.

PROF. WALL: Is there any danger of hydrolysis of the dichloroethylene with the evolution of hydrochloric acid and etching of all metal parts? There is hydrolysis in contact with water.

MR. LINDSAY: We have not experienced any. We get free hydrochloric acid if we burn it, but it burns with a very slow flame. Methylene is, of course non-inflammable. In order to guard against rust where water has got into a machine, we have taken the occasion to coat some of the machines with zinc.

VISIBLE RADIATION FROM THE LOW PRESSURE MERCURY ARC

By F. BENFORD

Synopsis

In this paper no attempt is made to give a complete analysis of the low pressure mercury lamp, but attention is confined to a few of the characteristics that are of most importance to the user of the lamp. A brief description of the physical construction of the lamps used in the test work is followed by a spectrophotometric determination of the energy distribution in the spectrum. Data on tube brilliancy and on causes of depreciation are given in their relation to photometric outputs, and some typical figures for tube life are discussed. The photometric distribution curves of both A.C. and D.C. lamps are given, both as bare tubes and as units complete with reflectors. The section on electrical characteristics gives some recent test data, and several of the most important reactions of the tube to ambient temperature are used to call attention to the factors to be watched during photometric tests. The concluding section gives briefly some of the conflicting phenomena that have contributed not a little to the present uncertainty about the reactions of the human eye under this light.

Introduction

The mercury arc in some of its many forms is to most of the members of the Society a light source with which they come into daily contact. It can hardly be brought before you as a novelty or a new contribution to the field of illumination, for the mercury arc is a true contemporary of the motion picture art and their two histories are so intertwined as to seem like one. But within the last two years a considerable amount of research has been carried out with the idea of getting a more intimate knowledge of this interesting, and highly individualistic light. As a result of these photometric researches and investigations, which are mostly of a rather elemental nature, several interesting and important features were brought to light. It is highly probable that some of the discoveries are really rediscoveries; but they will be here recorded because they will be new to a majority of the members.

The scope of the investigations included photometric, electric and temperature characteristics and at the present time preparations are under way to carry the work into the near ultra-violet region that is of such importance to the photographer. This latter part of

* Illuminating Engineering Laboratories. General Electric Co. Schenectady.

the work is not far enough advanced to give the careful analysis that the standards of this Society demand, and therefore the present paper is limited strictly to visible radiation.

1. *Physical Construction of Lamp*

The tubes used in these experiments are 1 inch in outside diameter and 50 inches in length between the end bulbs. The cathode consists of a pool of mercury contained in a flattened bulb that carries a short glass stem at its outer end. This stem contains the leading-in wire, which is submerged in the mercury, and during operation the current is carried by the mercury and the arc stream is in contact with the mercury surface.

The current heats the mercury principally at the point of arc contact and the vapor here formed increases the pressure in the tube from 0.002 mm cold to about 1 mm during normal operation. The pool is so proportioned as to operate at a lower temperature than the rest of the tube and it acts as a condensing chamber to collect any excess vapor and thus aids in keeping the vapor of the arc stream in a superheated condition. This thermal balance normally keeps the tube free from deposits of mercury, but if the tube stands without operating for a considerable time mercury droplets will form along the tube, only to be dissipated when the tube is heated.

The anode is made of soft sheet iron, stamped in a foliated design and then bent into a deep cup. The bulb containing the anode is but slightly larger than the tube. The anode is, of course, heated by the passage of current, but it does not reach a temperature of visible radiation. The arc contact is on the inside of the cup and it is spread out uniformly over most of the area and does not concentrate into a hot spot or crater such as is formed on the anode of a carbon arc.

The direct current tube has a single anode, while the alternating tube has two. The mercury arc has a low resistance for the passage of an electron current from mercury to the anodes, but a very high resistance for the passage of current in the opposite direction. The alternating current lamp is therefore so wired and connected to an auto-transformer that the alternating current of the supply lines is a unidirectional current through the tube. The rectification introduces wave distortions in the tube currents, and the total current is therefore not a series of sine waves, but is much more uniform. Due largely to the inductive action of the reactance coil that is in series with the lamp each cycle of current lasts more than half the time and

there is considerable overlapping of the two current waves for the two anodes. This reduces the effective current to almost a constant flow and there is no visible alternating current flicker in the lamp.

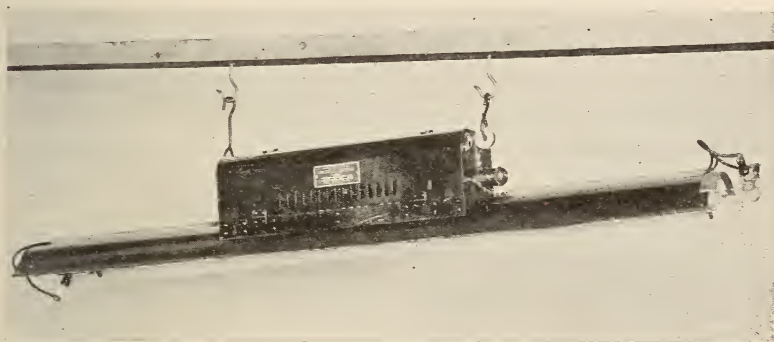
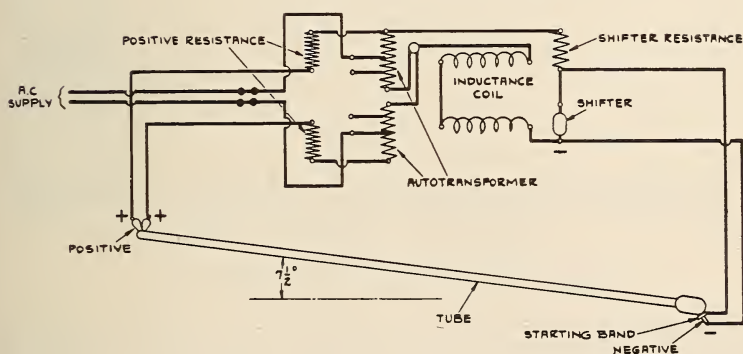


FIG. 1 Type of unit used in tests.

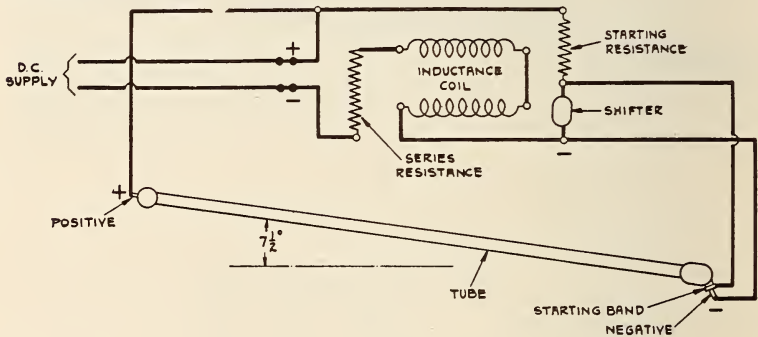


SCHEMATIC WIRING DIAGRAM OF ALTERNATING CURRENT COOPER HEWITT LAMP

FIG. 2. Wiring diagram of alternating current unit.

The lamp is started by an inductive kick from an inductance coil connected in series with a resistance coil and a mercury switch. Upon applying voltage a current of about an ampere flows through the switch and the resistance in series with it. When the switch automatically opens the resistance circuit a high inductive voltage

is applied between the cathode and a metal band around the stem of the cathode, and also over the length of the tube. This band does not make electrical connections with the inside of the tube, and part of the starting action is therefore of a static nature. The passage of a static spark from the surface of the mercury ionizes sufficient gas to make it a conductor that can be broken down by the relatively low applied tube voltage. To aid in the generation of the starting spark the cathode chamber is entirely covered outside with a metallic paint that adds, by a condenser effect, to the size of the initial static discharge.



SCHEMATIC WIRING DIAGRAM OF DIRECT CURRENT COOPER HEWITT LAMP

FIG. 3. Wiring diagram of direct current unit.

The outer tube diameter on a group of 70 measured tubes was found to be 0.961 inches, with a wall thickness of 1 mm leaving a bore of 0.0885 inches, and an inner area of 138 square inches. This area determines the area of the arc stream, and it helps determine the average intrinsic brilliancy.

2. Energy in the Visible Spectrum

A determination of the distribution of energy in the visible spectrum of a mercury arc has been made by spectrophotometric methods. This type of test is ordinarily made with a radiometer, but the use of photometric methods is to be preferred in the present case on account of other tests made on the mercury arc with the same instrument.

An incandescent lamp was calibrated at a color temperature of 2954°K and the energy distribution was computed from Planck's radiation formula. This lamp was used to illuminate a block of magnesium carbonate in front of one slit of the spectrophotometer, and the arc was placed directly in front of the other slit. The width of the eye-slit was predetermined so that the light from any given spectrum line would fill only about one-third of the telescope slit. By

SPECTROPHOTOMETRIC TEST
LOW PRESSURE MERCURY-ARC
COOPER HEWITT ELECTRIC CO., HOBOKEN, N. J.
DIRECT CURRENT TUBE, TYPE F

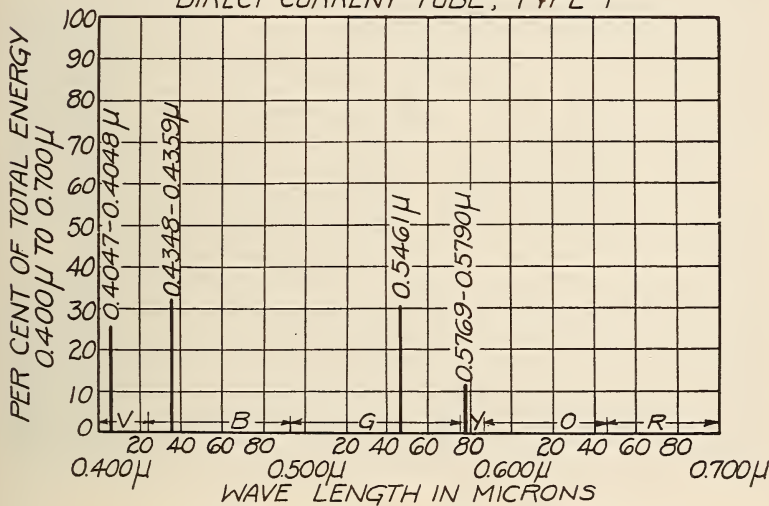


FIG. 4. Distribution of energy in visible spectrum.

observing this precaution the reception of the entire energy of each of the mercury lines was insured.

The spectrophotometer was equipped with a glass prism and consequently the dispersion of the spectrum was not uniform. The opening of the telescope was therefore computed in terms of the range of wave-length that would pass at any given setting, and from this computation the amount of emitted standard light was derived.

There is apparently not much information available on intensities of the spectrum lines of mercury, and perhaps the reason for this is that most of the research workers using this arc have been interested in the positions and formations of the lines rather than their strength. Also, as used experimentally the current density and tube tempera-

ture are apt to be highly variable and this would most likely disturb the relations between lines.

Taking the entire energy in the spectrum between the limits 0.400 $m\mu$ and 0.700 $m\mu$ as 100%, the distribution with a 3.5 ampere tube was found to be

Wave-length	0.4047-0.4078	$m\mu$	(violet)	25.33	per cent
"	0.4348-0.4359	$m\mu$	(blue)	32.60	" "
"	0.4916	$m\mu$	(blue green)	0.14	" "
"	0.5461	$m\mu$	(green)	30.90	" "
"	0.5769-0.5790	$m\mu$	(yellow)	11.04	" "

If the above energies are reduced to light values by multiplying by the sensitivity curve of the eye the following light values are obtained.

Violet	0.06	per cent
Blue	1.37	" "
Blue-green	0.17	" "
Green	73.30	" "
Yellow	25.10	" "

In some of the published data, which are evidently intended to be largely diagrammatic, the energy intensity of the pair of yellow lines is given as greater than any of the others. It seems to the writer that this distribution would give a light with a yellow green tone in place of the familiar blue-green. The above analysis with the green light greatly predominating seems to fit in better with the other data of the lamp, particularly the high camera speed of this light.

3. *Tube Brilliancy*

Illuminating engineers and others dealing professionally with light are always interested in the intrinsic brilliancy of light sources and doubtless the same interest exists, although in a different form, among the people working in motion picture studios. It is evident that mercury vapor has strongly marked radiation and absorption characteristics, and these factors determine the form of the distribution curve and the brilliancy of the tube as viewed from various angles.

An exploration for tube brilliancy at various angles shows the brilliancy to vary not more than 5 per cent for any angle within 70 deg. of the normal. This is somewhat surprising, for the depth of gas in the line of sight at 70 deg. is three times the diameter of the tube, and if the vapor were perfectly transparent the brilliancy

should rise to about three times the brilliancy along the normal. Some preliminary research along this line has been done, but the work is rather involved because it must take account of both the radiating and absorbing properties of the vapor, the polarization factors and the interference of the glass tube.

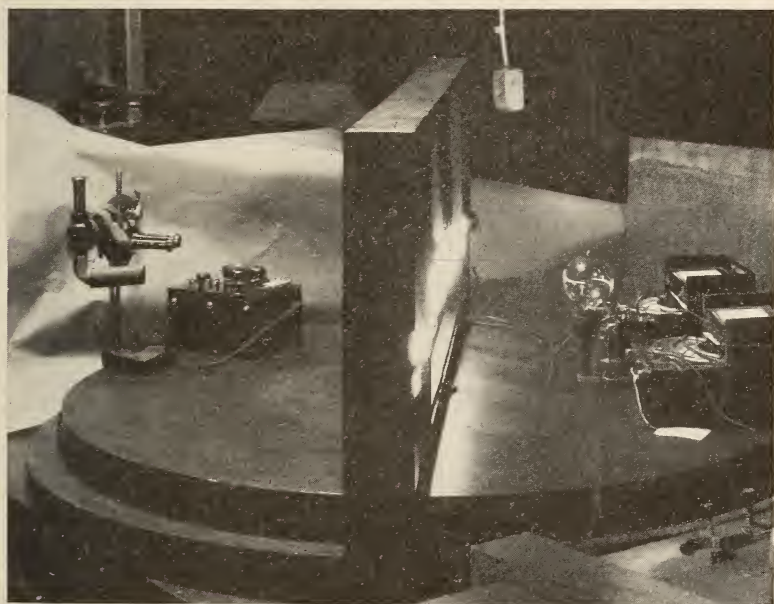


FIG. 5. Equipment for measuring tube brilliancy.

In Fig. 6 the curve gives the brilliancy of the tube as viewed through a slot one quarter inch wide and having a length of 2 inches along the tube axis. Taking the normal brilliancy as unity, there is a decrease to 0.99 at 15 deg. from the normal, then a gradual rise to a maximum of 1.07 at 50 deg. At higher angles the brilliancy drops rapidly, being only 0.58 at 80 deg. An inspection of the brilliancy curve shows why the photometric distribution so closely resembles that of a straight filament of uniform brilliancy at all angles.

It has been found that there is an inverse relationship between tube diameter and brilliancy. A decrease of one per cent in tube diameter leads to about a one per cent increase in light output and tube brilliancy.

4. Depreciation Causes and Rates

A mercury tube loses in quantity of emitted light as it becomes older in burning age, and some experimental work has been done to determine the causes and rates of this phenomenon. It has been

PHOTOMETRIC TEST
BRILLIANCY OF MERCURY TUBE FROM
VARIOUS ANGLES IN PLANE OF TUBE AXIS
DIRECT CURRENT

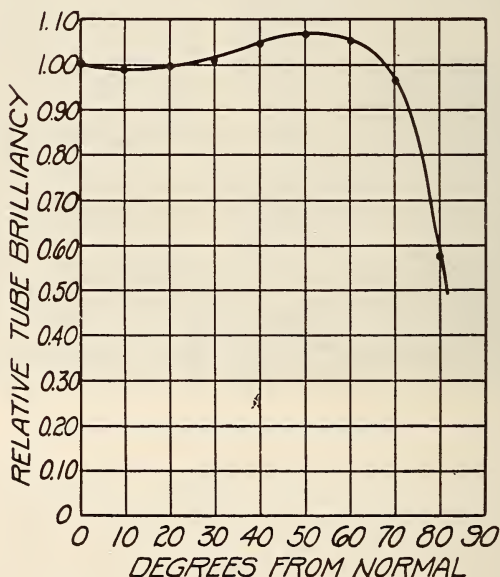


FIG. 6. Brilliancy analysis of mercury tube.

pretty clearly established that the blackening of the tube is the cause of the depreciation and not any change in the arc itself, nor in the glass of the tube. The tube ordinarily fails through loss of vacuum, and this is usually foreshadowed by the tube becoming a "hard starter." There is but little effect noticeable in the light output in the early stages of loss of vacuum, and the photometric output is not a sure indication of the probable life of the tube. This is in contrast

to the action in an incandescent lamp where a darkened bulb indicates a weakened filament and an increased probability of failure. The blackening agent in the mercury tube is iron from the anode, and as the wasting of the anode is not a factor in tube life there is but little relation between the state of blackening of the tube and the probability of failure.

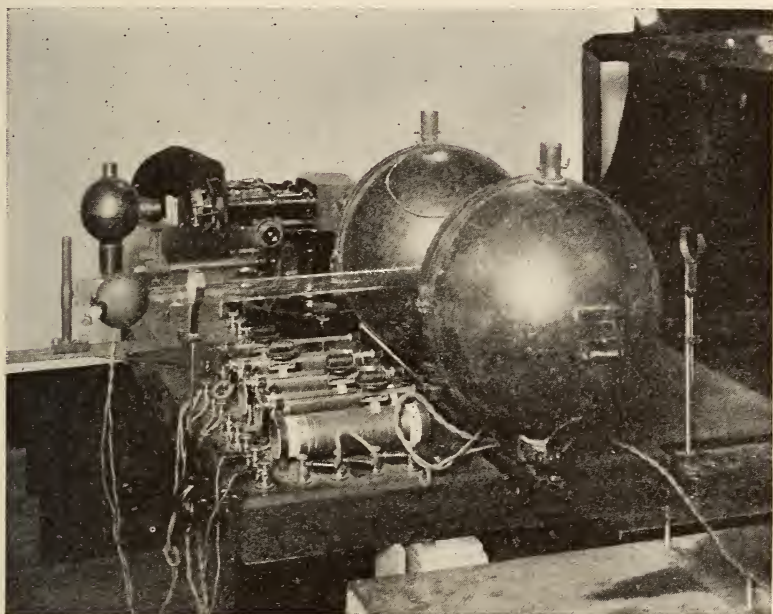


FIG. 7. Equipment for measuring transmission of tube.

The particular nature of the tube blackening has been demonstrated in several ways, and the glass in the tube does not seem to be discolored or darkened to any particular degree. In Fig. 8 the curve gives the measured transmission through a tube of light originating outside the tube itself. A new tube that has been operated for only a few hours transmits about 80 per cent of the incident light except near the mercury pool where a temporary deposit of mercury reduced the transmission to about 70 per cent. This deposit forms while the tube is cold and the size of the mercury drops that form it gradually increases as the tube stands. The entire deposit disappears when the tube is operated long enough to become thoroughly warmed. It

should be here remarked that this same tube has an efficiency of transmission for light originating within the tube of over 95 per cent, and the low values here recorded are largely due to surface reflections, which in the case of an interior source do not greatly effect the effi-

TRANSMISSION OF COOPER HEWITT TUBES
WAVE LENGTH 0.570

D.C. TUBE No. 8 ——— 834 HOURS
D.C. TUBE No. 56 - - - - - NEW

LIGHT PASSED THROUGH BOTH WALLS OF TUBE

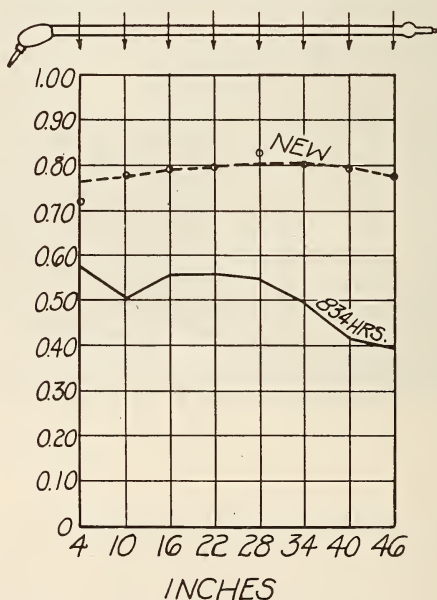


FIG. 8. Transmission factors of new and old tubes.

ciency. The reflection loss in these experiments is about 20 per cent, or practically the entire loss shown for the center of a new tube.

After a burning period of 834 hours the transmission curve of a certain direct current tube revealed a characteristic form that furnishes a clue to the cause of tube blackening. The section closest to the cathode showed a maximum transmission; then came a short

space of decreased transmission. From here to the center of the tube the transmission rose to 56 per cent and then decreased continuously to 39 per cent near the bulb of the anode. This minimum next to

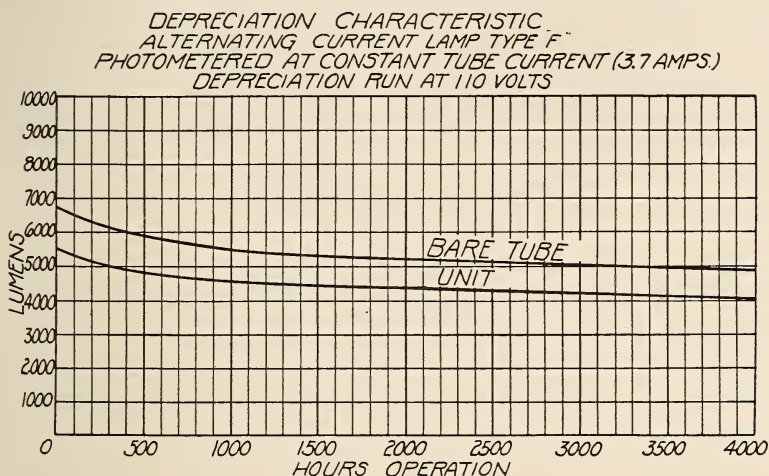


FIG. 9. Depreciation characteristics of A.C. tube and unit.

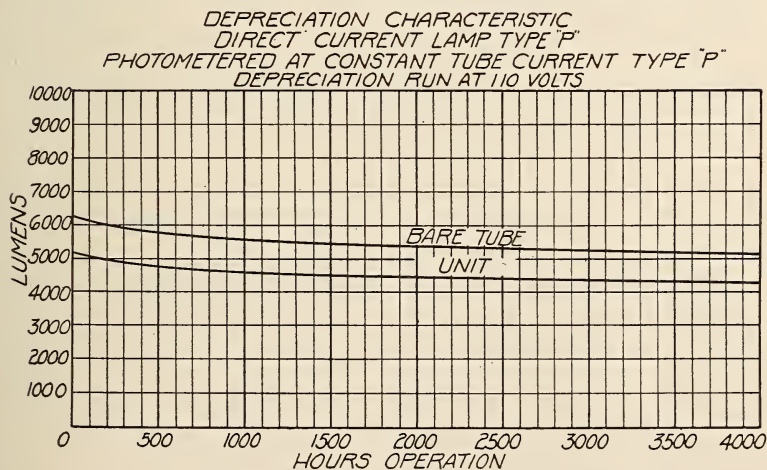


FIG. 10. Depreciation characteristics of D.C. tube and unit.

the iron anode has been observed in every test and it is fair evidence of the guilt of the anode as the principal cause of depreciation.

The depreciation rate of bare tubes under normal operating conditions is given by the upper curves of Figs. 9 and 10. The rate of

change becomes so small after several thousand hours as to require the most careful type of photometry to measure it accurately. Thus in the first 1000 hours of life the loss of light from one group of direct current tubes was observed to be slightly over 10 per cent, but the same tubes between burning ages of 3000 and 4000 hours depreciated only 2 per cent, and this lower rate seems to be maintained about constant for at least 10,000 hours. Some few lamps that have survived to 40,000 and more hours warrant the belief that the deprecia-

*AVERAGE LIGHT CHARACTERISTIC
ALTERNATING CURRENT TYPE F*

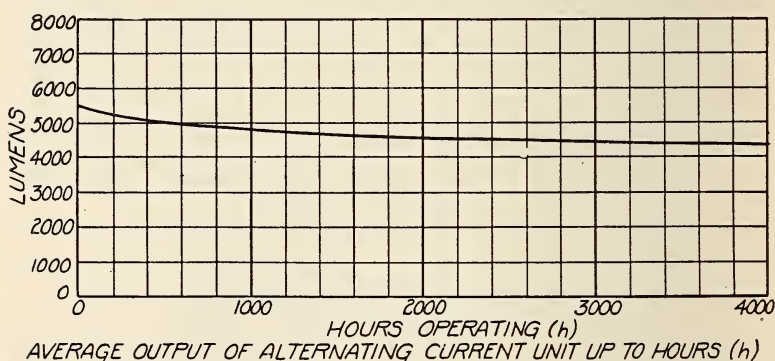


FIG. 11. Average light output for any given life.

tion rate continues to drop up to these exceptional ages where the ordinary risks of operation permit only a minute fraction of the tubes to survive.

The rate of depreciation can be changed by altering the current through the tube. This is a result to be expected if blackening is a result of iron being vaporized off the anode. A series of tests made under overload conditions showed unmistakably that the depreciation rate was increased, but there was no satisfactory data obtained on the total life, or time of tube failure. The test was made on a circuit where the voltage fluctuated widely during certain hours of the day, and the average overload of 6 to 8 per cent in voltage is not a fair measure of the effective overload, as it is measured in tube blackening. The test did demonstrate, however, that the rate of depreciation rose with the voltage, but there is no clear evidence that the life of the tube is shortened by excess voltage or current.

5. Life Test Data

To those mystics who believe man to be a loquacious brother to the silent stone there should be comfort in the resemblance of the mortality rate of man and mercury tube. A group consisting initially of twenty-four tubes was tested for over 6000 hours and record was made of the survivors at various elapsed times. This group was too small to give precise data (assuming the possibility of such a thing)

LIFE CHARACTERISTICS OF MERCURY ARC TUBES
24 TUBES TYPE P

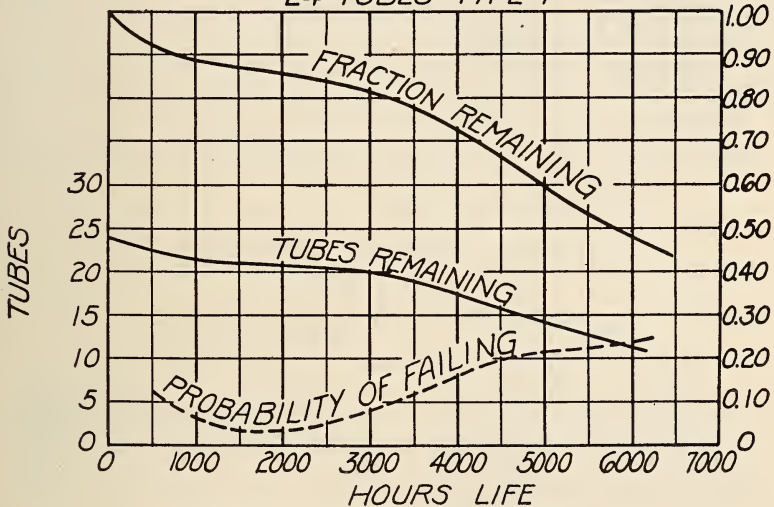


FIG. 12. Sample life probability data.

but the characteristics noted below have been observed in other groups and the generality of the data can hardly be doubted. In laboratory tests the temptation to occasionally place the tube in the photometer is too great to be resisted, and hence we have no exact knowledge of how long a tube could be expected to burn if left undisturbed.

During the first 1000 hours the tube mortality was high, amounting to 11 per cent of the total number, and 2500 hours were required to reduce the tubes a second 11 per cent, after which the mortality rate rose, and from the evidence of the test it would continue to rise for all longer periods. When the data are reduced to the probability of an "average" tube dying during any particular period we get the following figures. In the first 1000 hours the chance of failure is

0.11; during the second 1000 hours the chance is 0.03; during the third 1000 hours the chance rises to 0.05 and it is only after 3000 hours that the chance of failure rises to the initial value of 0.11. After this the chance increases steadily to 0.20 during the period

*PHOTOMETRIC TEST
ALTERNATING CURRENT COOPER HEWITT TUBE AND MECHANISM TYPE F
110 VOLTS (TERMINAL), 3.7 AMPERES D.C. (TUBE CURRENT DURING TEST)
438 WATTS (RATED)*

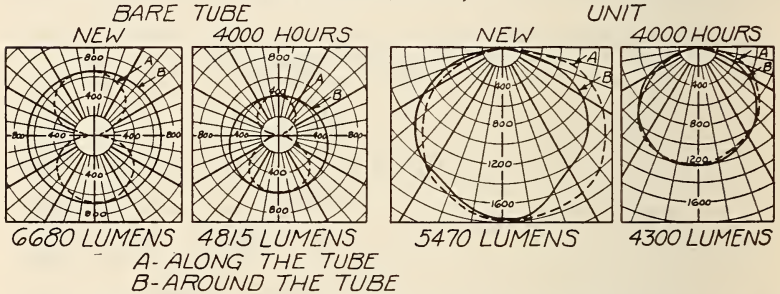


FIG. 13. Photometric distribution of A.C. tubes and units.

*PHOTOMETRIC TEST
DIRECT CURRENT COOPER HEWITT TUBE AND MECHANISM TYPE P
110 VOLTS (TERMINAL), 3.5 AMPERES, 385 WATTS
BARE TUBE*

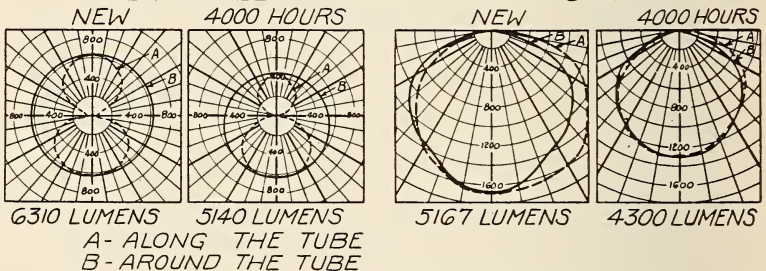


FIG. 14. Photometric distribution of D.C. tubes and units.

between 4000 and 5000 hours and 0.22 during the period between 5000 and 6000 hours.

The general resemblance between these rates and the mortality rates of humans will be recognized. During infancy the rate is high and falls to a minimum during the ages between 10 and 15 years. This corresponds to the period between 1200 and 2400 hours in the life of a tube, and both mortality curves rise continuously thereafter.

There is at least one authentic case of a tube burning 40,000 hours, but this is as unusual as the humans who are reported to have

have lived 150 years, and in both cases we are entitled to suspect that during the last third of their existence they were interesting solely on account of their age.

Accurate life data are difficult to obtain. In shops and studios the failure of tubes is often occasioned by accidental causes, and not

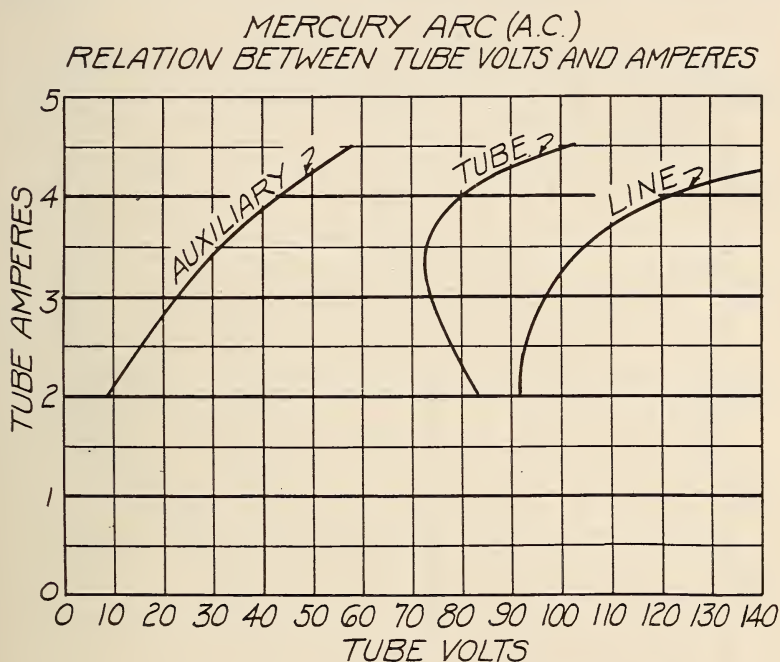


FIG. 15. A.C. volt-ampere characteristics.

to a failure of the seals, which seems to be the normal inherent cause of tube failure.

6. Photometric Distribution

A new mercury tube, that has not been blackened by burning, radiates light almost exactly as if it were a straight wire filament. In another place some of the reasons for this have been gone into in some detail, and for the present attention will be confined to the distribution changes that take place as the tube blackens, and to the effect of using a reflector.

It was found that the deposit of black material that forms with age is much more dense along the top of the tubes, and in some cases

the top has been found to be very distinctly blackened with no visible trace of blackening along the bottom. Tubes vary among themselves, and instances have been found of nearly uniform distribution around the tubes. The general rule is however for the upper part of the tube to blacken at a much higher rate than the bottom and this leads to

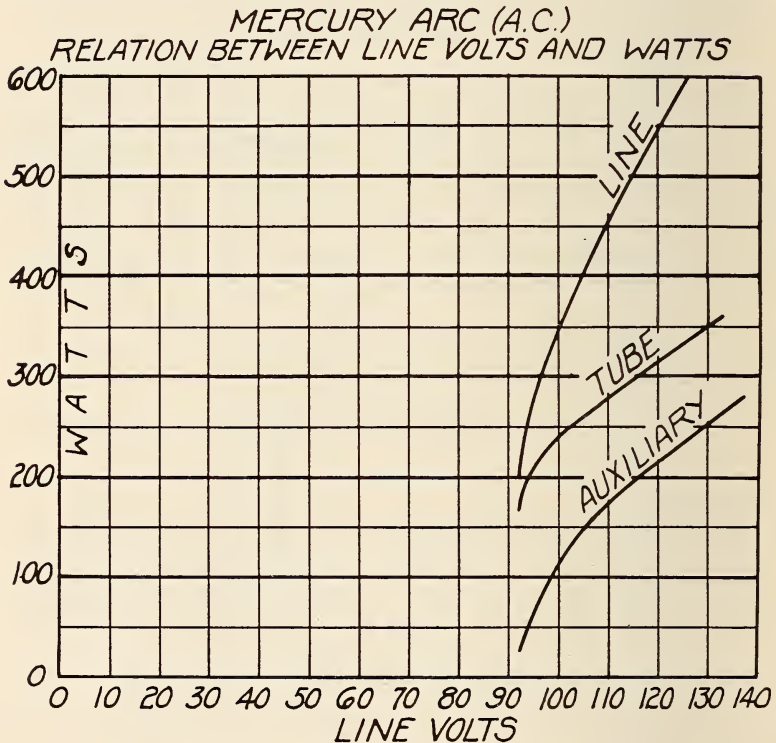


FIG. 16. A.C. volt-watt characteristics.

several secondary effects that are of importance both to the photometrist and to the engineer.

The primary effect of the greater degree of blackening that takes place along the top of the tube is to reduce the upward intensity in a much greater degree than the downward intensity. In the particular case of a certain D. C. tube the loss at 4000 hours life was 18.6 per cent for the whole tube, but the loss directly downward was so small as to make its measurement a matter of some difficulty. The upward loss was 33 per cent, measured along a line vertical to the tube. An

A. C. tube that lost 27 per cent in 4000 hours showed a loss along the downward normal of 10 per cent. It has been found that the relation between the upward loss and the downward loss is extremely variable in different tubes, as has been mentioned, and the reason for this

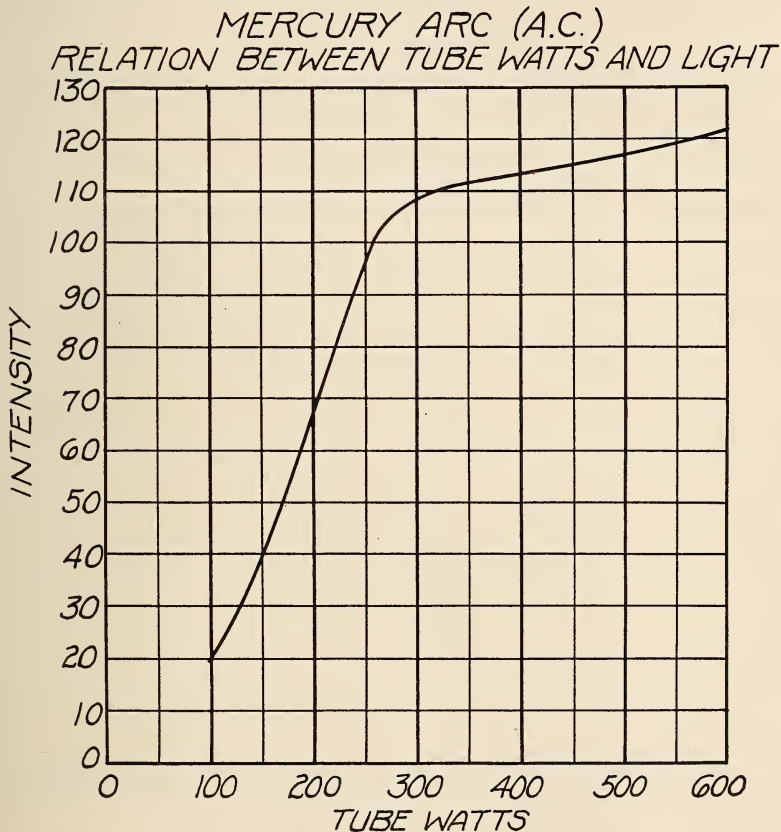


FIG. 17. A.C. watt-light characteristics.

variation is not clear, particularly when it appears in a group of lamps that have been operated under what seem to be nearly identical conditions.

The reflecting surface used in these photometric tests was the usual equipment that is part of the unit. The curvature of the reflector is that of a circular cylinder, with the axis of the tube so placed as to secure a strong downward reflection such as would be

obtained with a light source at the one focus of an elliptical trough. The reflector comes below the bottom of the tube and all direct upward light is cut off. The net change is rather surprising, for the straight line distribution is changed into that from a luminous disk facing downward. This condition makes it easy to perform certain

MERCURY ARC (A.C.)
RELATION BETWEEN LINE VOLTS, LIGHT AND EFFICIENCY

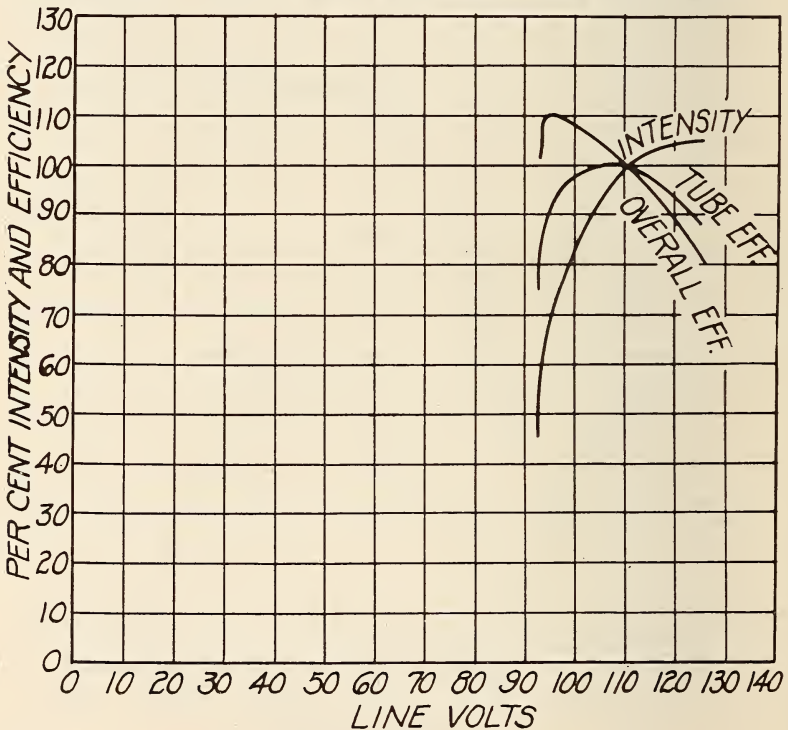


FIG. 18. A.C. volt-light characteristics.

computations of illumination which are much simpler when dealing with a symmetrical source.

As the tube ages the resemblance to a disk increases and the distribution in any vertical plane becomes closely a circle.

The efficiency of the reflector is influenced in a unique way by the selective blackening of the tube. In ordinary photometric parlance the efficiency of a reflector is the output of the lamp with the reflector divided by the output of the lamp alone. As a result of this usage the

efficiency of a reflector is influenced by its intrinsic reflecting power, its angular method of reflection and by the degree in which it encloses the lamp. As a general rule the efficiency of a reflector is increased

ELECTRICAL CHARACTERISTICS

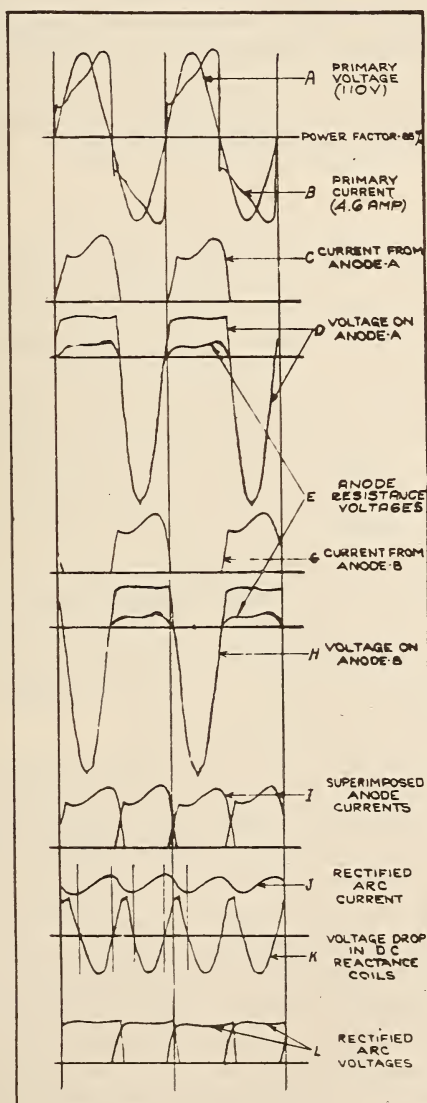


FIG. 19. Oscillograph record of A.C. unit.

when the amount of light falling upon it is decreased by withdrawing the lamp somewhat from the reflector. If, during ageing, the tube materially changes its distribution characteristic the result will be much the same as if the lamp were shifted outward with respect to the reflector. In the case of the mercury tube the percentage of light falling upon the reflector decreases continuously during the life of the tube and the initial reflector efficiency of 81.9 per cent has been found to increase to 83.5 per cent at 4000 hours tube life. This rise is believed to be unique as all other units depreciate at a rate that is greater than the bare lamp depreciation rate.

7. *Electrical Characteristics*

The low pressure mercury arc is a true arc in many of its electrical characteristics, but it differs in some respects on account of the confining effects of the glass tube. The usual arc between carbon electrodes is free to expand in diameter and change shape as the current grows, but in the case of an arc confined within glass walls the growth in diameter is limited and when this limiting action is well under way the arc alters its normal arc reactions and acquires an inherent stability. As an example, it has been found that the light output is altered when the tube diameter is changed, and the arc is vastly more sensitive to ambient temperatures than the carbon arc which operates in a manner that seems totally independent of room temperature. This dependency is one of the reasons why precision photometry of the mercury arc is almost out of the question, but with proper attention to test conditions an agreement to within a few per cent can be expected in most of the photometric and electrical measurements that are customarily made.

One of the unusual features of the alternating current lamp is the voltage characteristic as measured across the lamp. The voltage is, of course, composed of a positive and a negative wave during each cycle, but only one of these waves is effective in producing current, and the effective wave is altered greatly from the original sine formation. The technical difficulties of correctly measuring individual circuits are such that they are best avoided if accurate photometry is attempted, and for this reason the alternating current tubes were operated on an equivalent direct current during the photometric part of the investigation.

The run-away nature of the arc is overcome by the confining action of the tube plus enough resistance in series with the arc to

give the combined resistance a positive coefficient so that an increase of current is accompanied by an increased total voltage drop. Because of the almost unvarying active length of the arc the mercury lamp is normally more steady than an arc that is free to move and change its shape.

The mercury lamp is somewhat unique among illuminants in having a rather definite point of maximum efficiency for any given

TEMPERATURE CHARACTERISTICS OF MERCURY TUBE
AT 25°C. [FINAL AMBIENT]

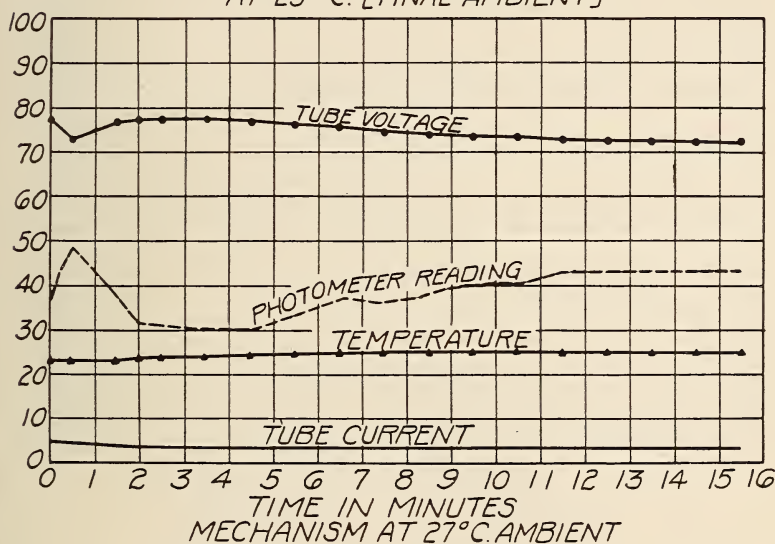


Fig. 20. Temperature characteristic at 25°C.

design of tube. The practical side of this characteristic is that care should be taken to operate the lamps at rated electrical conditions.

The starting characteristics of the direct current lamp are given in the next section, where the effects of ambient temperature are discussed.

8. Temperature Effects

The mercury arc is responsive to ambient temperature, and this fact is of particular importance when photometering the tubes. Care must be taken to have the tube in a stable thermal condition; otherwise, the photometric results may readily vary as much as 50 per cent. In general, a slow progressive air temperature change is

not followed by any large response from the tube, although there are upper and lower temperature limits beyond which it is not wise to go. As an illustration of the reaction of the tube to ambient temperature the curves of Fig. 20 may be compared with those of Fig. 22 for temperatures of 25°C and 66°C respectively.

TEMPERATURE CHARACTERISTICS OF MERCURY TUBE
AT 46.6°C. [FINAL AMBIENT]

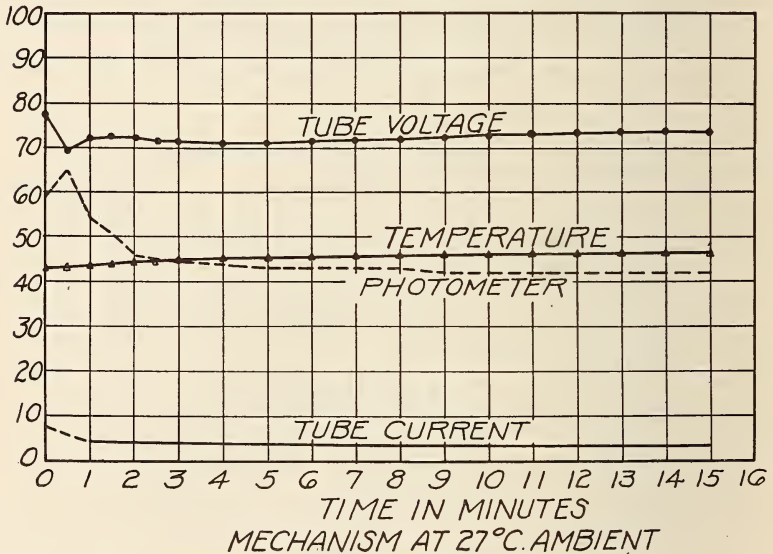


FIG. 21. Temperature characteristic at 47°C.

These tests were made with a constant voltage of 110 volts across the terminals of the mechanism, which was separated from the tube, the latter being in a 2-meter sphere with a heater and fan for controlling the ambient temperature. The tube was not started until the ambient temperature had been held at the test level for 15 minutes.

At every test temperature between 25°C and 66°C the light output was at a maximum during the first half minute of operation, and following this the light decreased sharply. At the lower temperatures there was a gradual recovery in output after from 2 to 5 minutes, but at the higher temperatures the output decreased steadily to a constant value at 8 or 10 minutes. These relations are plotted in Fig. 23 where the shaded area represents the range of photometric values

obtained at ambient temperatures between 25°C and 66°C. At temperatures around 30°C a premature reading taken before the tube has had time to come to thermal equilibrium may yield values 15 per cent high or 25 per cent low, depending upon the particular time of reading, but at 50°C and above, premature reading may be 60 per cent or more above the readings taken when a stable condition is reached. As a result of these relations an attempt to photometer

TEMPERATURE CHARACTERISTICS OF MERCURY TUBE
AT 66° C. [FINAL AMBIENT]

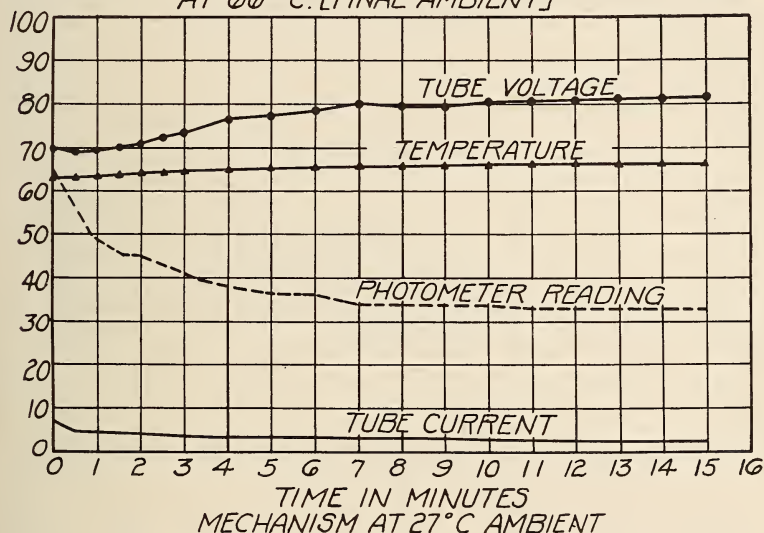


FIG. 22. Temperature characteristic at 66°C.

mercury lamps under varying temperature conditions will often yield erratic test data, and if the temperature fluctuates rapidly as the tube is subjected to varying draughts of air the photometer reading will often pass beyond the range indicated in the diagram. The terminal voltage curves of Fig. 23 show two of the factors that contribute to forming lower and upper operating temperatures. The tube operating voltage at low temperature is abnormally high and this, in connection with a lower rate of ionization by the starting mechanism, leads to hard starting. At temperatures of 5°C and below the lamp is started with difficulty and this is a very real practical limit. The upper limit, due to high operating tube voltage, is not of much practical importance, being over 100°C and possibly as high at 125°C. These

temperatures would be encountered if the lamp were installed directly over a furnace, or the rolling table of a glass or steel mill.

9. Reactions of the Eye

The subject of the influence of the discontinuous spectrum of the mercury arc upon the human eye is, in certain circles, one that

TEMPERATURE CHARACTERISTICS OF MERCURY TUBE. —MECHANISM AT CONSTANT TEMPERATURE— —110 TERMINAL VOLTS—

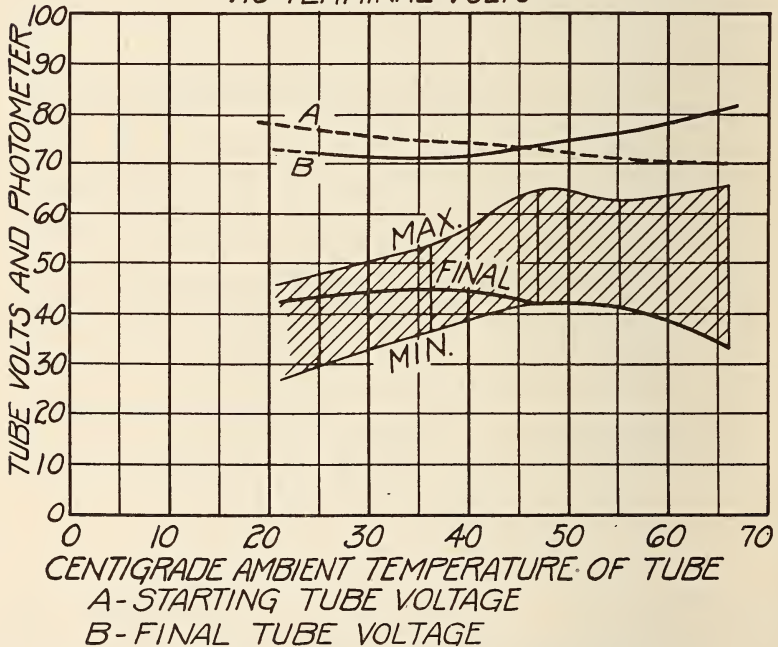


FIG. 23. Summary of temperature characteristics.

is approached with caution, and the wise writer must always be prepared to make a strategic retreat, gracefully if possible, to less contentious ground. In the last 25 years many experiments have been made and many results obtained with but little agreement among them. Too often the results reflect the technique of the experiment rather than the characteristics of the light, but out of the mass of accumulated data certain facts seem to emerge.

Perhaps the first fact is that mercury vapor light is not harmful, in spite of the terrible things it does to the most carefully prepared

complexion. This does not mean that by poor engineering the light may not be made harmful, for misplaced light of any character is dangerous, and the eye knows no exception.

The second fact is that there is a distinction in the reaction of the eye to mercury light that is different than to any other light. The iris of the eye responds to levels of illumination, being large in diameter for low levels and small for high levels. It also responds to quick changes of illumination so that the diameter at any given moment is determined not only by the illumination of that moment but also by the previous illuminations for a number of minutes back. These changes are not so prominent when the illumination is from a mercury vapor lamp, and the difference in reaction is due to the fact that the controlling factor is the amount of infra-red (invisible) radiation present. These particular wave-lengths are weak or missing in the mercury spectrum and the iris remains wider open than would be the case for other light. This leads to three secondary reactions and has been the cause of endless dispute.

The amount of light that enters the eye and the brightness of the image depend directly upon the area of the iris opening. Hence the mercury light for equal energy in the visible spectrum should produce brighter images on the retina than other illuminants. In photometry both types of light are received simultaneously and it would seem that the iris would be influenced by the infra-red of the standard lamp to take a diameter smaller than normal for the mercury light above. This leads to the belief that all measurements made between an incandescent standard and a mercury arc are conservative in value.

The lens system of the human eye has two main optical defects that are common to all natural and artificial lenses. Different colors are refracted to different focal planes, the violet image lying in front of the principal image plane, and the red image lying behind it. Thus every image formed in the retina has a color fringe, but we have in some manner achieved the useful faculty of ignoring these colors, but even if ignored they still have an effect on acuity, or ability to distinguish details. In the mercury spectrum the red and orange parts are missing, and the spectrum length is reduced by over one-third. This reduces the color fringe and as a result the acuity is increased, often to a very useful extent.

The outer parts of the lens are brought into action when the iris opens; and these parts are particularly defective in their chro-

matic focusing. Thus two opposing actions take place in comparing the mercury spectrum with a black body spectrum. The limited length of the visible mercury spectrum makes for acuity and the open iris tends to decrease acuity. The predominance of one or the other factor determines the relations between acuities under the two types of spectra.

In addition to the chromatic errors of the outer edge of the lens the curvature is also defective (spherical aberration), and the outer edge is inferior to the central parts in producing a clear image. Here again the discontinuous spectrum with a wide iris is at a disadvantage as compared with a continuous spectrum and a more restricted opening.

Even this brief outline of the factors that influence visibility show the complicated nature of the phenomena, and it is evident that the effects due to the fundamental differences between mercury arc and continuous spectrum lights is not easily evaluated. Some of the same relations exist in photography, but this is not the place to discuss this companion problem.

DISCUSSION

MR. PALMER: I should like to ask Mr. Benford a question about the constancy of light from a mercury arc, either A.C. or D.C. In making motion picture titles with a mercury arc, as the light source, the exposures become very short—about 1/50th of a second, and it is claimed frequently that the irregular illumination of the titles on the screen is due to the fact that the light changes in value during short intervals, and I should like to know whether he has made any measurements or can give us any data.

MR. BENFORD: I am sorry to say I cannot answer the first question. I have never tried that. I do know that for ordinary photometry a lamp will be constant between ± 5 per cent. In that respect it is surprisingly good when you are trying to get accurate data in a short time, but I don't know what would happen in shorter times.

MR. MAYER: Mr. Benford's comment on the efficiency increase of the lamp with the reflector fitting as the lamp blackens is a little hazy to me.

MR. BENFORD: In photometric circles we speak of the efficiency as the reflected light divided by the bare lamp light. If the lamp gives 1000 lumens and only 800 lumens when put in a reflector, the efficiency

is 0.8. In the case of the mercury arc, due to the lamp giving off less and less light in the proportion upward, the reflector became less and less concerned with what was going on.

DR. HICKMAN: This deposit of iron which gets through; does it deposit on the walls in mirror form or is it black? I took it that it deposits on the tube. Is this practically black, non reflecting?

MR. BENFORD: It is practically black; it has little shine to it. Any light that hits it is a dead loss.

MR. L. A. JONES: I am very interested in Mr. Benford's remarks relative to the spectral distribution of energy in the radiation from the mercury lamp. We have not made any radiometric measurements but when necessary have used data taken from the literature of the subject. I have always felt that the value of energy for the yellow line was too high. This opinion is based on photographic photometric measurements. In actual practice the yellow line does not produce as great an effect as is indicated by the values commonly given.

I presume that Mr. Benford also realizes that the distribution of energy varies somewhat with time. In using this light source for photographic purposes we frequently determine the effective "color temperature" of the lamp. Of course it is impossible to determine a true color temperature for a source of this type. We find that it requires 10 or 15 minutes for the lamp to reach an equilibrium from the standpoint of energy distribution, the "color" becoming effectively yellower as the lamp continues to burn. It appears that the intensity of the blue lines is relatively high at the instant of starting, gradually decreasing with respect to the yellow and green components as the lamp continues to burn. If the mercury lamp is used as a standard for photographic measurements we find it necessary to let it burn at least 10 or 15 minutes before making exposures.

MR. BENFORD: The lamp burned for half an hour before readings were taken, starting at one end of the spectrum, going to the other, and returning. The first and last readings on the same line checked satisfactorily, so that I felt I had reached stable thermal conditions. I do not know what the color composition would be short of that period of time.

MR. CRABTREE: The D.C. mercury vapor lamp appears to visibly flicker at times. Perhaps Mr. Benford will explain what controls flickering. Also, are there any advantages in using an A.C. over a D.C. lamp? If so what are they?

MR. BENFORD: I believe that if you are troubled with flicker, it may be from the service lines. There is a small inherent flicker but with the proper voltage I can hardly conceive how this would be troublesome. With regard to A.C. and D.C., I believe the D.C. is inherently a little superior, on account of its steadiness. Most of our service lines are A.C. at least a great number, and for that reason the A.C. has certain commercial advantages; but the fact that the mercury arc is a rectifying device, it is obvious that one should use D.C. when freedom from flicker is desired. I do not recall having seen visible flicker with a D.C. lamp.

MR. R. C. HUBBARD: Bearing out what Mr. Benford has said, in our title department, we have found the flicker with tubes very noticeable. Changing to D.C. tubes has eliminated all noticeable flicker.

MR. JENKINS: I should like to ask if Mr. Benford has any data or can cite any source with regard to the time period—building up from no light to a maximum and also a period of light extinction. We want to project motion pictures by radio and must have a rapid valve and a constant light or a very rapidly changing light-source. As most of you know, the only motion pictures ever made by radio vision have used a Neon light-source, which we have been using for some time, but obviously it has its limitations. One can not make a very big picture till we get a stronger source. There are two ways open: one is to get a stronger light-source, which will vary without decrease in the spot, or get a valve that will control a constant source of light of high intensity.

MR. BENFORD: My measurements were made in terms of minutes. The quickest time of reading is 5 to 6 seconds, which is too long for you.

MR. BURNAP: I think this question might be answered by saying that since this is a gas discharge it follows the same laws as all gas discharges. The change in light output for current change is instantaneous, which is true of all gas discharges as far as can be measured.

MR. CRABTREE: There is a matter of terminology of light sources of this nature. What term would be used to differentiate this from an incandescent lamp or filament? I brought this up in connection with a later paper by Dr. Engl, in which he uses the term "glow-light."

MR. BENFORD: I think when we refer to "glow," we refer to some of the discharges that surround the electrodes and have light zones in the tube. I think that is the ordinary conception. When you

have a continuous arc between the electrodes, you speak of it as an arc, whether in the tube or in the open.

MR. PORTER: In co-operation with Mr. Foulks of the Cooper-Hewitt Company we have been making some interesting tests on mercury-arc, Neon, and incandescent lamps used for aviation beacon purposes and have been finding some interesting things. We have been trying to find out which makes a more conspicuous beacon when viewed through fog. Due to the very great amount of energy of the mercury vapor lamp emitted in the yellow-green or blue-green end of the spectrum, to which the eye is very sensitive. We anticipated that mercury would make a good beacon observed at forty or fifty miles, but it is not so good as the Neon or the Mazda. We have been led to the conclusion that the light of the mercury lamp is absorbed very much more rapidly by slight haze, i. e., either absorbed or scattered, than light nearer the red end of the spectrum. I wonder if Mr. Benford has any measurements on the absorption of light. the air.

Another interesting thing we have noticed is that a light of different color is quite valuable when viewed among many surrounding lights. It is easier to pick it up even at 6 or 7 miles, and at close range the pinkish color of the neon and greenish color of the mercury are equally valuable with regard to color contrast to the city lights, but as you go out to greater distances, the Neon seems to lose its color contrast, whereas mercury retains its conspicuous green as far as you can see it. I should be interested to know if Mr. Benford has data along those lines.

MR. BENFORD: About ten years ago I measured the transmission of the atmosphere and found a surprising thing. Tests were made over a horizontal course of half a mile, and the weather was thick; it was distinctly misty. The transmission was about 57 per cent, which would correspond to poor seeing at night. I was very much surprised when I plotted the data to find that the transmission was almost identical with that of a dry atmosphere from a mountain top. I think I can draw a curve which will illustrate it. The transmission is 100 per cent. The transmission curve is very low in the violet and blue and rising to a maximum in the extreme red. Here is where the mercury arc falls down on this job. The energy is concentrated over the part of the low transmission. The red Neon has its energy concentrated in that region where the transmission is high. This is for a half mile; if that test had been made over 3 or 4 miles with identical

conditions, the curves would be different, as at long range or in thick weather the Neon would be working on one part of the transmission curve and the mercury arc on another.

PROF. WALL: Some years ago, about 1880, the main streets of London were illuminated with Wenham gas lamps, and some one thought it would be a great advantage to put in arc lamps. We had one day the worst London fog on record and all lights were switched on. It was found that the arc lights merely illuminated a small area, just close to the standards and in between was complete darkness. So the gas lamps had to be lighted with some considerable improvement. It is remarkable how, when looking down the length of a street in a fog, the lights get redder and redder the more distant they become, the blue and violet rays being completely absorbed. With regard to the emphasis laid on the yellow rays, is this not due to the fact that these, with the red and green lie nearer the maximum of the visual luminosity curve?

MR. BENFORD: I think it is a matter of atmospheric transmission. When the air is thick, there is an enormous difference between transmission in the yellow and red. You might get a hundred times as much red as yellow, so that red is the only color that gets through at all.

MR. BRIEFER: I should like to ask Mr. Benford if he has made any measurements on the sensitivity of the mercury vapor arc lamp, to temperature changes. What I have in mind is, that when the lamp is in practical use in printing laboratories, drafts from open windows or ventilating fans may produce some condensation of the mercury vapor, with consequent diminution of light intensity and hence, such printing density changes as have been described in this discussion. Would it not be advisable to suggest to those who make use of this lamp, to shield it from cooling drafts and provide some means to keep the temperature surrounding the lamp reasonably constant.

MR. BENFORD: The lamp will react to drafts. If you suddenly change the temperature of the tube, you get all sorts of erratic results, as I found to my sorrow. If you allow the lamp to come to a stable condition it is almost constant; But while things are changing the arc is adjusting itself to some temperature equilibrium and you will get flicker. It is therefore, worth while to shield it.

MR. BRIEFER: Color blindness has nothing to do with visibility of the nature mentioned by Mr. Wall. It is a fact that the red rays are much less scattered than the blue and intermediate. A yellow

light of low intensity should have better penetration in water fog than a blue light of high intensity. Probably the arc lights were placed at a high elevation to avoid the blinding intensity of the scattered rays.

MR. JENKINS: It is unfortunate that my job is always the application of things in a new way, so that I am looking for these things. Why should we not use the red for photography under water? I should think the conclusions drawn here would lead to that.

MR. W. C. HUBBARD: I do not think that Neon lamps have been available in sizes sufficiently large to do this under-sea photography, but the mercury vapor arc has been used successfully and is about to be used again using quartz or high pressure burners enclosed in pyrex cylinders closed at each end and hung in numbers on iron frames range the pinkish color of the Neon and greenish color of the mercury are equally valuable with regard to color contrast with the surrounding city lights. As you go out to greater distances, the Neon seems to lose its color contrast, whereas mercury retains its conspicuous green as far as you can see it. I should be interested to know if Mr. Benford has data along those lines.

The lamps are started on the deck of the steamers and plunged overboard, submerged to various depths for lighting the bottom of the sea and for doing under-sea photography. This method was first used 12 or 13 years ago. An expedition has been formed to go to the Islands of the Pacific to explore the coral fisheries. It would be interesting if some large Neon bulbs or lamps could be sent along and tried out successfully.

PRELIMINARY REPORT OF THE S.M.P.E. SPECIAL COMMITTEE ON STUDIO LIGHTING

December 15, 1926

REGARDING the effects of the method of studio illumination upon the health of the actors and other studio employees, the subject is an intricate one which has many obscure ramifications. A complete statement of these conditions would necessarily involve an elaborate study from the standpoint of the Illuminating Engineer, the physiologist and a careful statistical medical investigation. There are, however, certain features which are so well known by the personal experience of everyone who has dealt with arc lamps that definite recommendations as to procedure in order to prevent any severe and immediately dangerous results in the use of arc lamps can be made at the present time.

It has been the experience of workers with flame arcs and mercury arcs enclosed in quartz and other light sources which radiate a considerable amount of ultraviolet that severe and painful burns of the eye occur after a comparatively short exposure to these light sources. This ultraviolet burn when experienced in the motion picture studio has been called "Klieg eyes." This is an inflammation of the outer membranes of the eye ball. The trouble develops usually from 12 to 24 hours after exposure to the causative radiation. The condition is temporary and usually clears up completely within 4 to 5 days. It is not an injury to the retina of the eye or to any of the interior elements of the eye as some people have supposed. The best work which has been done on this subject indicates that the outer coating of the eye, the cornea, the crystalline lens, and the humors absorb the ultraviolet light so strongly that it is almost impossible for any of the radiation to reach the retina itself.

Of all of the papers which have been published on this subject which one of the members of this Committee has been able to obtain, it seems to us that the one by F. H. Verhoef and Louis Bell* is by far the most complete and authoritative treatment. Their conclusions are very positive that the commercial artificial light sources can not, even under the most unfavorable conditions, cause any

* The Pathological Effects of Radiation on the Eye, F. H. Verhoef and Louis Bell Proc. Amer. Acad. Art. Sci., 51, 1916 pp. 630-818.

Same title, somewhat abridged, Trans. Illum. Eng. Soc., 16, 625, 1921.

serious injury to the eyes if ordinary glass is interposed between the light sources and the eye. There is no doubt, however, that such sources as the white flame arc, high intensity arc, ordinary hard cored carbon arc, when used without any glass whatever, may cause the very painful although temporary condition known as "Klieg eyes."

Ultraviolet radiation also produces an inflammation of the skin which later develops into a tanning that is practically identical with severe sunburn. It is also a well known fact that sunburn and tanning and other physiological action from natural sunlight is practically absent when the sun shines through ordinary window glass. Physiological experiments conducted with quartz mercury arcs and other sources of ultraviolet radiation have indicated practically no physiological action when the light from these sources was passed through ordinary types of glass and such physiological action could be obtained only when special glasses of extremely high ultraviolet transparency were used.

One of the members of this committee, who is now the Illuminating Engineer of one of the largest motion picture studios, states that in his experience of 15 years around a motion picture studio he has never seen a single case where there was any permanent injury to the eyes of a worker from exposure to light. "There were frequent cases of temporary eye burns before we began putting glass on the lamps, but this has practically disappeared now, and it is only occasionally when a man takes a chance in working near an open arc that we have trouble."

From these well known facts the committee feels justified in stating that provided great care is used to enclose all arc lamps used for studio illumination with some sort of glassware there will be no danger that ultraviolet burns will occur in the studio. There sometimes exists an impression that provided the arc lamps are directed towards some portion of the set in which no action is to take place that ultraviolet burns could not result. This, however, may be misleading as many objects would reflect enough ultraviolet to be dangerous.

In discussing the relation of studio lighting to health conditions in the motion picture industry, it must be borne in mind that direct sunlight such as is much used in motion picture photography has powerful physiological effects, and has been known to be fatal in some cases where persons unaccustomed to exposure to it have suddenly been subjected to long continued sun baths at the seashore,

in the desert, or on high snow-covered mountains. The Committee does not view this condition with alarm. The painful effects of a sudden overdose of direct sunlight are so well known to outdoor workers that the necessary advice of caution will doubtless be given to novices working with any responsible motion picture company. With very few exceptions immunity from any harmful effects due to even continuous exposure to direct sunlight is soon acquired. Short outdoor scenes are usually taken with no thought of harmful effects of sunshine and actors would naturally spend part of their time outdoors in the sunshine anyway. These rather obvious statements regarding sunshine are not included in this report not so much as warnings as they are to indicate the degree of severity or otherwise of the physiological effects of artificial studio illumination. These effects with glass enclosed arc lamps are much less than with direct outdoor sunlight. Persons who are not injured by direct outdoor sunlight will not be affected by glass enclosed arc lights.

It has been suspected for a long time that there are physiological effects of radiation other than the middle and far regions of the ultra-violet which are definitely known to cause sunburns, eye burns and the like. The ultraviolet just next to the visible portion of the spectrum, ordinary visible light, and high intensity infra-red radiation have been suspected or accused of undesirable effects. Such more or less obscure effects may possibly exist although at the present time there is no definite proof that they have any great action. Whatever effect is present is probably small and would not appear except under prolonged exposure. To detect any possible effects due to these radiations would require careful investigation by competent medical authorities. Such investigation and research might be desirable for the Motion Picture Producers and Distributors to have undertaken. If it is their desire to do so the Committee would be glad to cooperate in the selection of competent authorities.

A word of caution can not be omitted as to the dangers of too great visual intensity if in direct line with the direction in which a person is required to look. Glaring lights of high intensity which blind the eyes temporarily are known to have deleterious effect upon the eyes of persons compelled to look at such lights continuously for a long time. It is suggested that lights toward which an actor is compelled to look should at least be covered by a diffusing screen so that bright points of high intensity glare will not be in his field of vision.

The ordinary precaution of adequate illumination in all parts of the studio to prevent accidents should be provided. The Illuminating Engineering Society has developed a code of recommended lighting practice which can be utilized if further information on this subject is needed.

DISCUSSION

PRES. COOK: I suppose you all know that at our Briarcliffe meeting, Mr. Hays asked us to have an investigation made of the influence of studio lighting upon the actors and others exposed to it, and in response to the resolution of the Board of Governors, the Executive appointed a committee composed of Dr. Gage, Mr. L. A. Jones, and Mr. Palmer to investigate and report upon this. That report was handed to the Hays organization I think about January and was received by Mr. Hays with great appreciation and given a good deal of publicity. I have asked Dr. Gage to give you this morning the report which was prepared at that time for the Hays organization.

MR. COFFMAN: Pardon me for introducing a personal experience, but I have suffered such painful effects from ultra-violet radiation and which were peculiar to the medical profession that others may benefit from my statements. A year ago last December I was making some films under conditions which demanded all the illumination I could get from the lighting line which came into the building. In order to increase this as much as possible, we used the arcs without diffusers, and it was necessary for me to stand up in front of these arcs. Like most motion picture men, I became somewhat afraid of the effects but after three days' work of that kind I left, and at that time felt nothing but the most extreme fatigue. I put it down to the hard work I had been doing, but my lower limbs began to swell and I suffered excruciating pain. I mentioned it to physicians, and when I spoke of the lights they smiled indulgently and pronounced it rheumatism. It got worse, and the pain later occurred in the arms as well as the legs; and along the paths of all the blood vessels in the legs the flesh began to turn red and got hard. There were no signs of infection, but within two weeks the lower limbs were as hard as stone, and it was impossible to move with anything like normality although I had a tendency to keep moving. I found that in bed I suffered greater pain, and it was more difficult to get up again, so that I dragged myself out of bed in the morning

and went town to the office with the aid of somebody or on all fours, but I felt better on my feet than I did before. That lasted about two and a half months, and I was being treated by the best physicians in New York. Most of the prescriptions had like effect. All color disappeared from my face, and there was no sign of pigment in the lips; people began to call me a dead man. Finally, Dr. Snook, of the Bell Telephone Laboratories, hearing about the case informed me that he had seen somewhat similar cases although none of them quite so severe and that the effect was caused by destruction of the red blood corpuscles. The symptoms were those of pernicious anemia as well as suffocation, because no oxygen was being disseminated to the parts of the body. The only thing was to let nature take its course, and I have been in good health ever since; but some physicians were so completely uninformed as to effects of this sort that they actually prescribed ultra-violet treatment. I did not take their advice; probably if I had I would not be here to tell the tale. You will excuse the remarks I make, for the experience has had such a tremendous influence on me that I feel impelled to warn everybody to avoid the ultra-violet. Incidentally, Dr. Snook said that one attack sensitizes to others, which I have found to be true and which seems to make it worth while recording the case, because whenever a slight dose of ultra-violet reaches me, I have the feeling of fatigue.

MR. L. A. JONES: The case reported by Mr. Coffman is indeed interesting. In going over the literature and discussing the subject with physicians, I have encountered a few cases of injury from over exposure to radiation which appear similar to Mr. Coffman's experience. There seems to be some definite evidence that extreme over exposure to short wave radiation can cause injury to the blood corpuscles. I should like to inquire if there was any impairment of vision.

MR. COFFMAN: Only temporarily, but no permanent impairment. One effect I did not mention, was complete destruction of all normal reflexes. Physicians do not believe I am insane, but until this last month they could not get any reflex, except in the eye.

MR. L. A. JONES: There is little doubt that an injury resulting from over exposure to ultra-violet does sensitize to subsequent exposure. I know of cases where an actual retinal burn due to over exposure to the direct radiation from the iron arc has been produced. Persons having suffered this injury are extremely sensitive to even

small amounts of ultra-violet radiation, this being evidenced usually by the production of head ache almost immediately upon exposure to even very low intensities of ultra-violet. I think there is little doubt that a serious injury resulting from over exposure to ultra-violet may produce a very sensitive condition to subsequent exposure.

REPORT OF PAPERS COMMITTEE

PREPARATION of the program for the spring meeting was commenced in January 1927 and an advance program was circulated to all members three weeks in advance of the meeting. Only six papers were submitted voluntarily, two of which were from abroad. The fact that scientists in foreign countries are anxious to publish their researches in our Transactions is a good indication of the increasing prestige of our Society. It was necessary for your Chairman to solicit most of the remaining papers and even to suggest the titles. It will probably always be necessary to approach authors in this manner although under these circumstances it is possible to construct a suitable program rather than accept a variety of miscellaneous papers which may not necessarily be of topical interest.

As a result of much pressure, about 75 per cent of authors have submitted manuscript in advance. Previewing of manuscripts is very necessary in order to eliminate any blatant advertizing matter, while it is possible to correct the manuscript so that it can be handed over to the Publications Committee immediately after the meeting. Although 3 or 4 weeks must usually elapse after the meeting for correcting discussions, it is hoped that in this way some of the delay which has previously existed in issuing the Transactions will be avoided.

For the first time in the history of the Society several papers have been secured from members in Hollywood.

Your Chairman has taken the liberty of placing at the end of the program all papers which will not be presented personally by the authors.

At the suggestion of the Chairman of the Publicity Committee short abstracts have been prepared of all papers and will be available for representatives of the press.

J. I. CRABTREE, *Chairman.*

J. A. BALL.

C. E. EGELER.

L. A. JONES.

REPORT OF THE STANDARDS AND NOMENCLATURE COMMITTEE

THE following items have received but one approval by the Society and should be ratified at this meeting.

External Diameter of No. 1 Projection Lens.

The external diameter of the barrel of a No. 1 projection lens shall be two and one thirty second of an inch ($2-1/32$ in.). (In metric measure 51.6 mm). Adopted TRANSACTIONS No. 24. Discussion in Nos. 19 and 22.

DISCUSSION

MR. MAYER: Why can not the dimensions be expressed in decimals, or in both ways? Our proceedings should record both because it is customary for all societies to express everything in decimals.

PRES. COOK: There is no reason, but since the first vote is on a fractional measurement, we could not in fairness change it at this time. The motion merely confirms the former vote on a dimension of $2-1/32$ inch.

DR. GAGE: This would involve changing over all dimensional standards. What I have done and am going to do, is to add the metric measurement. I think every manufacturer has a table showing the decimal equivalents of fractions.

MR. RICHARDSON: I think that members not present at the time this was originally taken up will not know what it is all about. It is simply a difference of opinion of the lens makers. We must adopt the standard. We can not compel manufacturers to adopt it in practice.

MR. MCAULEY: Have the lens makers been consulted? Very often tubing in fractional parts of an inch can not be readily obtained. If this has been taken up with them it is all right.

DR. GAGE: The makers have certainly been consulted. One manufacturer is already making lens barrels of this dimension, and we are asking the others to make them the same.

MR. JOHN G. JONES: I believe in fairness to the manufacturers, we should add plus and minus tolerances to the dimensions.

MR. GRIFFIN: I don't think it is necessary to specify tolerances. The method of mounting lenses in projectors, at present and in the future, is that they shall clamp in, so that tolerances are not required.

MR. PORTER: Theoretically, we should have tolerances on all dimensions adopted. On the other hand, as manufacturing processes improve, those tolerances are liable to be cut down, and it seems to me that we lay ourselves open to prolonged and indefinite argument if we try to set tolerances on our figures. I think if we set standards and let the manufacturers set their own tolerances, we shall do better.

MR. RICHARDSON: There is no tolerance necessary because the lens is mounted in a split ring.

(The motion for adoption of the dimensional standard for the No. 1 projection lens was passed).

Dimensions of film splices

At the last meeting it was adopted that film splices shall be made in accordance with the dimensions given in the figure (Fig. 1, p. 20, No. 27 Transactions) for laboratories and exchanges. This was held up at the request of Mr. Denison, but he agreed at the last meeting that this would be all right.

(Motion passed to adopt above dimensions.)

Perforation of positive film

The dimensions of newly cut and perforated 16 and 28 mm positive and negative, and 35 mm negative film have been approved

KODAK POSITIVE. PATHÉ POSITIVE.

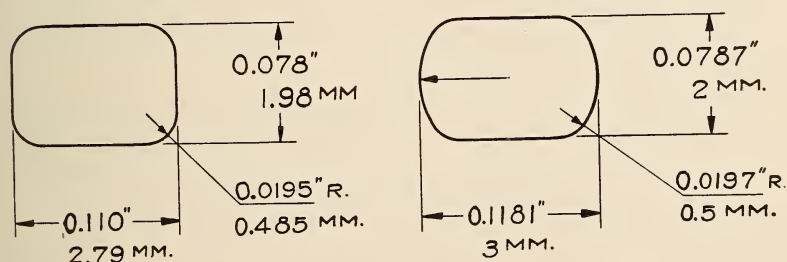


FIG. 1.

previously in accordance with the diagram printed on p. 8, No. 24 Transactions. Approval was also given to the following perforation dimensions for 35 mm positive film (see Fig. 1).

Either "Kodak" positive .110 inches (2.79 mm.) x .078 inches (1.98 mm.) with rounded corners as illustrated in the diagram Fig. 1 or the "Pathé" positive perforation .118 inches (3 mm.) x .0788 inches (2 mm.) with rounded ends and corners illustrated in Fig. 2, p. 9. No. 24 TRANSACTIONS.

We ask for a vote of second approval on this item.

DISCUSSION

MR. PORTER: Do I understand we are adopting both the "Pathé" and "Kodak"?

PRES. COOK: Yes, and there is no change in the dimensions of those adopted many years ago, the only difference being in the shape of the corners.

(Motion carried to adopt above dimensions.)

Camera cranking speed

The camera cranking speed of 60 feet per minute has received first approval in No. 24 TRANSACTIONS as follows: and should be ratified at this meeting.

A camera taking speed of 60 feet of standard film per minute with a minimum of 55 feet and a maximum of 65 feet should be used when normal action is desired, in connection with the Society of Motion Picture Engineers recommended (projection speed.) of 80 feet per minute.

DISCUSSION

MR. L. A. JONES: I should like to point out at this time that this question of taking speed will have to be reconsidered somewhat, if the reproduction of sound on the film come into practice. In reproducing music or speech it is necessary that the taking speed be the same as the projection speed. That is absolutely necessary for satisfactory reproduction of music, because of the pitch change. I think we should consider this because it is possible that film in the near future will carry sound records.

MR. RICHARDSON: I have thought of that, but I think talking pictures will have to be dealt with by themselves. We can not apply the same rule to the regular motion picture and the talking picture.

PRES. COOK: Gentlemen, there are two possibilities before us. Many years ago we adopted 60—somewhere around 1920 or 1921 or before that—and that was published for years in our book of Standards. At Roscoe it was again taken up and discussed, and at that time it was repassed at 60 with a tolerance of 55-65. We can either vote to eliminate that tolerance of 55-65, and in that case we shall merely confirm the ancient standard of 60 without tolerance, or we can vote to sustain that tolerance. I think it might be as well to get the sense of the meeting as to which is preferable.

MR. PORTER: I think the point that Mr. Jones has brought out is that with the increasing use of the recording of sound and pictures

on the same film we will have to take cognizance of it. I see no reason why we could not do this adequately by adopting recommended practice of 60 feet per minute for cases where pictures only are recorded on the film, stating definitely that an exception is made for pictures and sound recorded simultaneously.

PRES. COOK: I think we must consider that as new business. We are asking for the confirmation of that previously voted upon or the rescinding of it.

MR. PORTER: I think we are at liberty to modify it and lay it over for 6 months. I consider this in the way of modifying the first adoption, which will hold it over for 6 months before final adoption. I think this is better than rescinding or adopting it at the present time.

DR. GAGE: It is very evident with the speaking movies, that where the speech is on one edge of the film, we should have to change the dimensions of the aperture and have standards on speed and so on; but I think we should wait to find out what the manufacturers want as specifications for talking movies and then start out and draft a new set of specifications for such films, and let this matter come through for the kind of pictures we are talking about, which are not tied up with sound, thus clearing the decks of the present situation.

MR. PORTER: I think the last recommendation is good, provided our adoption is so worded that it makes it specifically clear that this refers only to cases where pictures only are recorded on the film.

MR. RICHARDSON: It seems to me that this is a case of too much delay. This was started at least 2 years ago, was laid over by two or three Conventions, and we have been bedeviled with it for several Conventions. I had well nigh forgotten about it. I believe before we adopt any camera speed, the Society of American Cinematographers should be consulted.

MR. PORTER: They have been in great detail.

MR. L. A. JONES: May I ask, is this a standard or recommended practice?

DR. GAGE: Recommended practice.

MR. L. A. JONES: I move its adoption.

(Motion carried to adopt above recommendations.)

Intermittent Gear Ratio

Listed among our Standards is the following which has received approval in the No. 10 TRANSACTIONS at a time when a second ratification was not required.

The movement of the intermittent gear shall be expressed in degrees of rotation during which the pin of the driver is in contact with the slot of the driven gear. For example, a gear in which the pin is engaged with the slot for one-quarter of a revolution of the driver shall be called a 90-degree movement; that in which the pin is engaged with the slot for one-sixth revolution shall be called a 60-degree movement, etc.

This is evidently Nomenclature and we ask that the rule of double approval of all Standards and Nomenclature be made unanimous by second approval of this definition and that it be listed under Nomenclature.

(Motion carried to adopt above recommendation.)

Sprocket Dimensions

In the No. 27 TRANSACTIONS is printed a report by Mr. J. G. Jones on the dimensions of sprocket wheels for projectors. The method of arriving at this standardization of sprocket dimensions, proposed by Mr. Jones, has I believe the approval of the Society. There has been raised an objection to the dimensions which Mr. Jones proposed for the take-up sprocket which is a hold-back sprocket. In the design of this sprocket it was assumed that if it is of such size that it corresponds to a film having a shrinkage of 2.92 per cent that no injury will be done to new film having zero shrinkage provided, of course, other considerations such as tooth thickness treated in this recommendation be complied with. It has been pointed out, however, that when perfectly new film is used, the last tooth of the sprocket wheel holds back the film until it lets go and, when it does so, there is a sudden jump of the film to the tooth just preceding it. Thus the sprocket of the dimensions recommended would give the greatest smoothness of action to film shrunk to 2.92 per cent but allows slipping from tooth to tooth in the case of new film. This slipping action for new film was not assumed to be in the least injurious. It has been pointed out, however, that the standard tension of the wind-up which is 16 ounces on the periphery of a 10 in. reel is perhaps five times that amount or five pounds when a new reel is started and the film is wound near the hub. This jumping action on the new unshrunk film when used on a hold-back sprocket adjusted for the maximum 2.92 per cent shrinkage is highly injurious and moreover does the greatest damage to new film which is presumably both more valuable and is tenderer than old film.

As a result of this the Committee in proposing a new dimensional standard has followed the general plan suggested by Mr. Jones, namely:

The take-up sprocket which is a hold-back sprocket on a motion picture projector should be designed to have the same pitch as the perforations on film which has shrunk to the maximum amount occurring in films of commercially useful condition as supplied by exchanges. The feed and intermittent sprocket are to have a pitch equal to that of the sprocket holes in newly finished film.

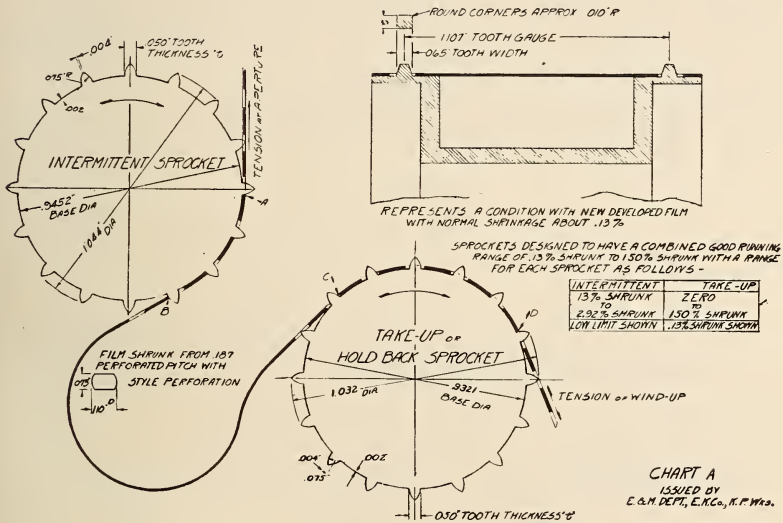


CHART A

Sprocket dimensions proposed by Society of Motion Picture Engineers

Intermittent sprocket with base diameter of 0.9452 in. (24.01 mm.) has same tooth pitch as the perforations of freshly processed film shrunk 0.13 per cent. Sprocket holes in theoretical contact with four teeth from A to B; i.e., the best running condition is for new film.

Take-up sprocket which is a hold-back sprocket with a base diameter of 0.9321 in. (23.67 mm.) is smaller and the tooth pitch is less than the perforations of newly processed film. There will be a slight clearance at the back of tooth C, also clearance between front of tooth C and all other teeth except the last tooth D which holds the film against the rewind tension. As the film leaves sprocket D, it will slip forward off this tooth until the slight clearance between the sprocket and the next tooth is taken up. If the take-up sprocket is too small the slipping from tooth to tooth is excessive and particularly damaging to new film.

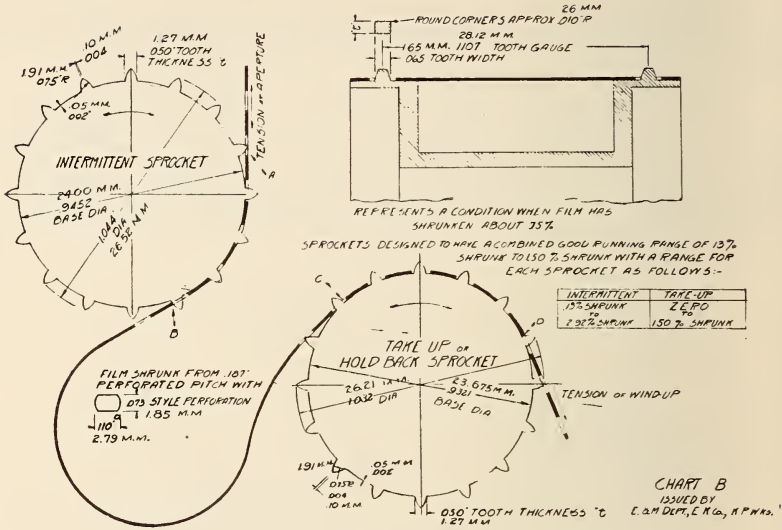


CHART B

Sprocket dimensions proposed by Society of Motion Picture Engineers with both English and metric dimensions

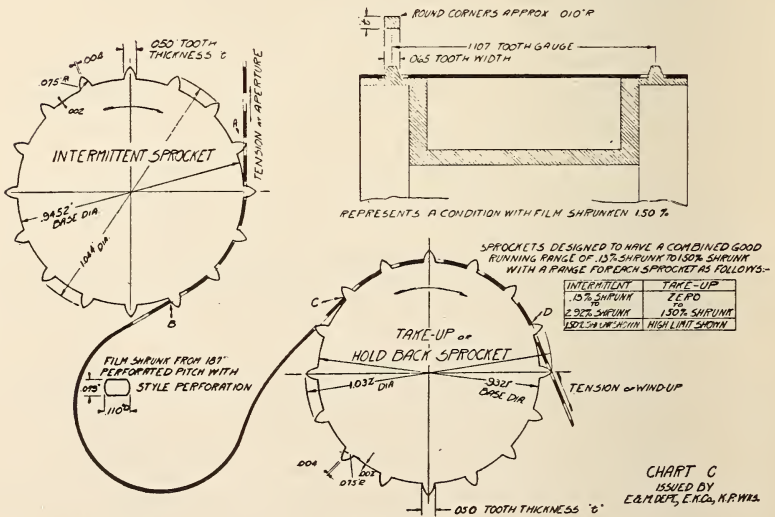


CHART C

Sprocket dimensions proposed by Society of Motion Picture Engineers

Film shrunk 0.75 per cent representing average film met with in service. Perforation pitch is slightly less than intermittent sprocket tooth pitch. The film is engaged by the last tooth B leaving a slight clearance at the other teeth. As film comes off tooth B, it is engaged by the next tooth. Motion of film is aided by the snubbing action between the film and the base diameter of the sprocket.

Film is held against rewind pull by the last tooth D of the take-up sprocket. There is increased clearance at the back of tooth C, hence no interference at the entering tooth. Compared to new film there is decreased slipping from tooth to tooth due to rewind pull.

Film shrunk 1.5 per cent representing oldest commercially useful film. Intermittent sprocket moves the film by the leaving tooth B. No interference by the back of the entering tooth A occurs until the film is shrunk 2.92 per cent.

Take-up sprocket has same tooth pitch as film perforations; i.e., the theoretically perfect running condition six teeth are engaged. If film is shrunk more than 1.5 per cent interference will occur at the entering tooth C and the sprocket holes will be torn.

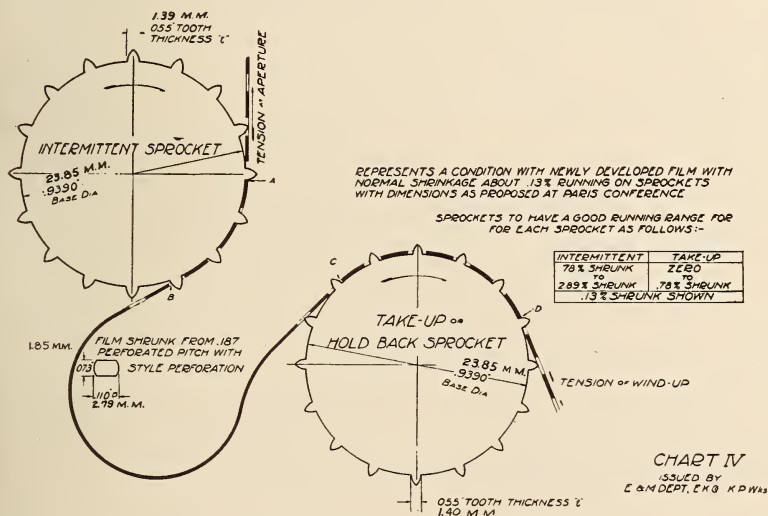


CHART IV

Sprocket dimensions proposed by the Paris Congress

Intermittent and take-up sprockets both have the same base diameter, 0.939 in. (23.85 mm.). The tooth pitch is that of the perforation pitch of film shrunk 0.78 per cent.

Film is shrunk 0.13 per cent. Entering tooth A of the intermittent sprocket engages the film perforation. When the next tooth engages film it pushes the film forward out of engagement with forward teeth. If tension is too great or film soft as in the case of new film the sprocket hole is likely to tear instead of pushing the film forward. *This condition is to be avoided as it causes damage.*

Take-up sprocket holds film against rewind tension by leaving tooth D and allows clearance to entering tooth C. This condition holds until film is shrunk 0.78 per cent.

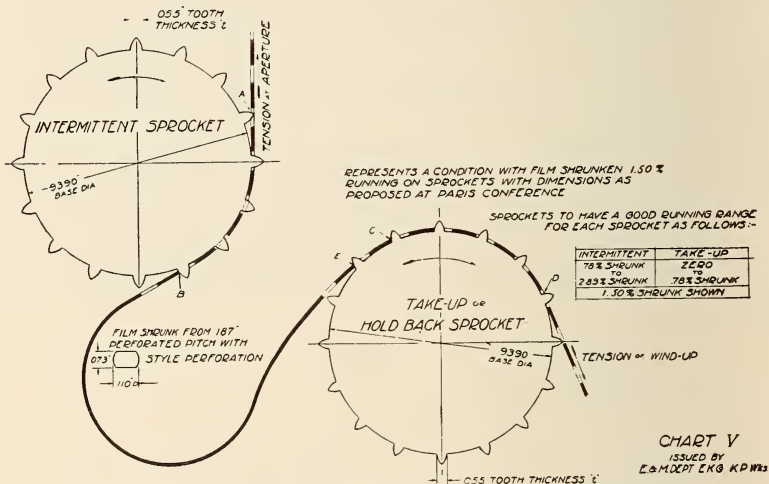


CHART V

Sprocket dimensions proposed by Paris Congress

Tooth pitch same as perforation pitch of film shrunk 0.78 per cent.

Film shrunk 1.5 per cent; i.e., old film.

Intermittent sprocket engages film at leaving tooth B leaving clearance at entering tooth A. This good running condition occurs at 0.78 per cent shrinkage and holds until film has shrunk 2.89 per cent.

Take-up sprocket engages film at entering tooth C. When next tooth E engages film, either (1) film is pushed forward, (2) film climbs sprocket tooth or (3) perforation is torn. This condition occurs at 0.78 per cent shrinkage and is more aggravated the greater the shrinkage.

The Committee finds that the maximum shrinkage of useful film is 1.5 per cent and recommends a take-up sprocket designed accordingly. The shrinkage of newly processed film for which the feed and intermittent are designed is 0.13 per cent. These latter sprockets as has already been shown will accommodate film shrunk as much as 2.92 per cent without damage. Dimensions of sprockets to produce these results are illustrated in Charts A, B, and C. The essential dimensions are:

For take-up Base diameter 0.9321 in. (23.67 mm.)

Sprocket

Tooth 0.050 in. (1.26 mm.)

For feed and

intermittent Base diameter 0.9452 in. (24.01 mm.)

Tooth 0.050 in. (1.26 mm).

(Motion carried to adopt above recommendations)

Ratio of Height to Width of Picture

In the No. 18 TRANSACTIONS it was voted as recommended practice that:

The existing ratio of three to four between height and width of pictures when introducing any new size of film should be retained.

DISCUSSION

MR. CRABTREE: This brings up the matter of pictures projected on a very wide screen. I suppose we should have to make other recommendations later on those apertures.

PRES. COOK: That would be similar to the music films. I may say for the benefit of the Society that Dr. Gage and I have met the assistant to the secretary of the Standards Society, who explained that any standards adopted by the American Engineering Standards are always subject to revision, and they have a tremendous amount of this in other branches. The procedure is much simpler to revise than to get it adopted in the first place, so that we are not taking an irrevocable step in adopting any standard.

(Motion carried to adopt above recommendation.)

Camera and Printer Aperture Sizes

In the No. 19 TRANSACTIONS it was voted as recommended practice that:

The camera aperture should be of such dimensions in relation to the projector aperture that a picture with black borders inside the projector aperture shall be projected.

In the No. 24 TRANSACTIONS for the Roscoe meeting of Oct. 5-8, 1925, p. 11, is found the following:

In regard to camera and printer apertures, your committee believes it to be consensus of opinion in the Society that the black border is desirable. To obtain it we recommend the following aperture sizes:

* Camera 0.700 in. high x 0.925 in. wide; 0.035 in. radius corner

Printer: 0.757 in. high x 1.000 in. wide; 3/64 in. radius corner

* Combination adopted as standard by the Incorporated Association of Kinematograph Manufacturers, Ltd.

Projector: (already standardized as 0.725 in. high x 0.950 in. wide; square corners)

The camera aperture corners may be either square or rounded, but the projector aperture corners must be square.

Page 12. Motion passed to adopt above dimensions.

It is evident that the Society seriously considered standardizing on the black border. However the size of projector aperture in continuous use by all American manufacturers since 1911 and the present official standard of the Society of Motion Picture Engineers is 0.6795 x 0.9060 inches. In the discussion of this proposed standard it was pointed out that it would be necessary to change the dimensions of the projector aperture. This has never been done and inasmuch as the above quotation states that the projector aperture is "(already standardized as 0.725x0.950 in. wide; square corners)" it does not appear in the TRANSACTIONS that the Society ever really intended changing the dimensions of the projector aperture but it merely assumed that the dimensions, 0.725x0.950 in., was the standard it had already adopted. As a matter of fact the dimensions given for camera, printer and projector are the dimensions adopted by certain British manufacturers the Incorporated Association of Kinematograph Manufacturers, and will give a black border. When, however, the same camera and printer aperture are used with the present standard projector aperture of 0.9060x0.6795, no border is visible. However, other dimensions of camera and printer aperture would give the same result; i.e., no border with the present small American standard projector aperture and black border with the larger British aperture.

In order to put into dimensional standard form the requisites for possible projection of black borders, the Committee recommends the adoption of alternate aperture dimensions. The adoption or rejection of these dimensions at the present meeting is a prerequisite for submission of our standards to the Engineering Standards Committee.

The dimensions suggested by the Committee are as follows:

Dimensions of Projector Aperture.

For the projection of pictures bounded by the image of the projector aperture, the projector aperture for standard film shall be sixty-seven hundred and ninety-five ten thousandths (0.6795 in.) of an inch (17.26 mm.) high by ninety hundred and sixty ten thousandths (0.9060) of an inch (23.01 mm.) wide.

(This is the present standard.)

For the projection of pictures with photographically produced black borders secured by the use of the standard size camera and printer apertures, the projector aperture shall be seven hundred twenty-five thousandths (0.725) inches (18.42 mm.) high by nine hundred fifty thousandths (0.950) inches (24.13 mm.) wide with square corners.

(This is the British Standard suggested as an alternate Standard.)

The following should receive second approval if the black border is to be used.

24 (Discussion printed in No. 18, letters from Mfg. No. 19 and No. 22)

Camera and printer apertures shall be as follows:

Camera 0.700 in. (17.78 mm.) high x 0.925 in. (23.5 mm.) wide; 0.35 in. (0.89 mm.) radius corners

Printer 0.757 in. (19.23 mm.) high x 1.00 in. (25.4 mm.) wide; 3/64 in. (1.2 mm.) radius corners

DISCUSSION

DR. GAGE: Consider what the adoption of the British aperture sizes might mean. Suppose that all pictures, taken by the producers after a certain time, were taken with this standard British aperture. We would then have films which will go through the present machines and look just as they do at present. When enough of these films were accumulated so that people would not get into trouble, it would be possible for the theaters to have the large apertures fitted into their projectors and to make whatever changes were required in the focus of the projector lenses used or possibly fixing up the screens so that they do not get into trouble with a painted black border, and as the theaters change over they will find that the films received from the exchange come out with the photographically produced black border. I would like to have the Society do something fairly definite about this at the present time, so that all matters will be straightened up so that we can deal with the American Engineering Standards Committee in a way which will be dignified and have some weight, and which will not be likely to be too easily upset.

MR. COFFMAN: Is the Society quite sure of its psychological grounds on this? As I understand it, the apparent object is to compensate for variations in the intermittent sprockets of the camera or projector. At any rate, if there is a variation on the screen because of inaccuracies in the sprockets, if the projector aperture is larger than that of the camera, you will have a large bright field moving

against a small dark one. In other words, you will have variations which should be more apparent than the motion of the field within a fixed frame.

MR. RICHARDSON: The idea was this: We have been projecting the picture a couple of inches over on the black border of the screen to hide the effect when the picture moves in the stationary aperture. The idea of this is that the opening will move with the picture; that is, the picture will not move with relation to the visible opening on the screen.

MR. JOHN G. JONES: For Mr. Coffman's information: We have had a film made and demonstrated before the Society on two occasions and the consensus of opinion was that the black border picture appeared more steady.

MR. TOWNSEND: The projection was not as practised in theaters. There was no permanent black border. It was projected on an open screen. While I have no authority to represent more than one theater, I want to go on record as being very much opposed to that practice. Distortion in the theaters is still present, and I predict that it will be there for a number of years to come, and when you put that black border in, you bring back the distortion and compel the theater to put the black border in further or use new lenses, which cost from \$50 to \$100 apiece.

MR. GRIFFIN: I think Mr. Townsend misunderstands the situation. The size of the picture within the black border as we have recommended is a little larger than the picture projected by the standard aperture, and it was discussed at great length at one meeting as to what would be best to do—let it ride and consider the error as there and not recognize it or recognize that it was there and not make another error. If angular distortion is present on the screen where the black border film is in use, it is expedient to use a standard aperture. Where they have an ideal condition, the black border serves two purposes; it serves to eliminate the idea in a person's mind of movement due to very tiny inaccuracies in the several machines through which the film passes before and during projection, and eliminates from view small particles of dirt that sometimes occur at the aperture. That is very bad, and inasmuch as the standard aperture can be used with that type of film, I do not see why it should not be adopted.

MR. JOHN G. JONES: It seems that it has not been made clear that this Society is not forcing the use of the black border. It gives the conditions if and when people want to use it.

PRES. COOK: For the benefit of the Society, it might be well to state whether this recommended practice is being followed by the makers of cameras in this country with which most of the pictures are being taken. Does any one know whether this corresponds with the camera aperture in general use? I would also point out that we have not very many members present who are as vitally interested in projection from an exhibitor's standpoint as Mr. Townsend, and possibly his being in the minority might not make it evident that the majority of exhibitors may take a different view from what we do from a theoretical standpoint.

MR. CRABTREE: Has this been discussed with the American Society of Cinematographers?

MR. JOHN G. JONES: The Standards Committee have worked out the dimensions for the apertures for the camera, printer, and projector, so as to project a black border. The dimensions arrived at were practically the same as those adopted by the Incorporated Association of Kinematograph Manufacturers, Ltd. Up to this time this matter has not been taken up with the American Society of Cinematographers.

MR. PORTER: I should like to remind this body that this black border was demonstrated twice at two different meetings 6 months apart, and it was the opinion of each meeting that it was desirable. I understand Mr. Jones has the films here and will show them again if the Society wants to see them.

PRES. COOK: The fact that we are favorably impressed with its desirability is hardly sufficient reason for its adoption, because there are many reasons why the present width of film might be considered too narrow for ideal results. The wider film might cause a better effect, but we should not think of increasing it, so that it seems to me that the fact that the picture has an obvious advantage made that way is hardly sufficient reason for its adoption, and it is my impression that most of those vitally concerned with the projection of these pictures will join Mr. Townsend in emphatic protest against the use of the black border. It is rather revolutionary to expect that the projectionists will adopt it. I think we should go rather slowly in the adoption of something quite so radical.

MR. PALMER: I think that Mr. Griffin has explained this in a very clear way which removes the objection that Mr. Townsend has. If you use the same aperture in the projector as is standard, you will not be bothered by the black border, and it is only the man who

wants the black border who needs to be considered. He can use a slightly larger aperture in his projector; it will be there if he wants it.

MR. TOWNSEND: I did not understand that that part of it was that way, but in raising the objection I had given it considerable thought. There are things encountered by projectionists that people who look at the shows do not understand. With the present standard we have of a frame line between the sprockets there is a variation from it which causes slight mis-frames. I get more complaints from the management because of slight mis-frames than for any other one thing, because the operator running the show has several other things to watch. He is looking at the picture at a distance of 160-200 feet, and the slight line apparent in the theater is not always visible to him. The more leeway we give him the better the picture will look. If you have the black border, unless absolutely correct, it will be too low or too high. I don't want to take a lot of time holding up anything, but I want to make my objections clear. I did not understand it would come outside of the present aperture.

MR. RICHARDSON: I do not think Mr. Townsend is quite as well in a position to judge of this matter because he looks on projection from almost ideal conditions, whereas this is particularly designed to take care of theaters having poor film and as a consequence a lot of movement. Another thing: Four out of five theaters have distortion, and this is cured by filing the aperture.

MR. GRIFFIN: I think Mr. Richardson does not quite understand. The size of the film picture is larger in all directions—vertically and laterally—than the standard aperture; therefore, when you file the edge of the aperture, you do not change the top and bottom.

MR. RICHARDSON: You will on the sides, because you make it more narrow at the bottom.

MR. GRIFFIN: The standard practice is to use a narrow aperture.

PRES. COOK: Is it not a fact that the point brought up by Mr. Townsend that the objection of the occasional appearance of the frame line would be very much aggravated by the presence of the black border? If it is hard to eliminate errors so great that the frame line will show, it would seem to require constant attention to prevent the frame showing at the top or bottom.

MR. GRIFFIN: I am inclined to agree with Mr. Townsend.

PRES. COOK: The effect of a frame line is very unpleasant and this would come in constantly.

MR. TOWNSEND: That is fundamentally my objection; it is almost instinctively so.

MR. GRIFFIN: I move that it be laid over.

(Motion passed to lay the recommendation on the table.)

MR. L. A. JONES: I suggest that the Chairman of the Committee take this up with the American Society of Cinematographers before the next meeting.

DR. GAGE: The question has come up now as to what are we going to do with dimensional standards. We are in a jam in this case of projector aperture sizes.

I should like to get the last two items off the list or get the projector aperture off the list pending second adoption.

PRES. COOK: Does the Chair understand that we have already adopted 0.6792 by 0.906?

DR. GAGE: Yes.

PRES. COOK: The object of the second one is to provide for the subsequent use of the black border which we have voted to lay on the table for future consideration. Would it be logical to adopt the projector aperture at this time without apparent justification for any change?

(Motion made, seconded, and passed to lay the recommendation on the table.)

TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

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Volume XI, Number 31

MEETING OF SEPTEMBER 26, 27, 28, 29, 1927

LAKE PLACID, N. Y.

The Society of Motion Picture Engineers

Its Aims and Accomplishments.



THE SOCIETY was founded in 1916, its purpose as expressed in its constitution being, "advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein, and the maintenance of a high professional standing among its members."

The Society is composed of the best technical experts in the various research laboratories and other engineering branches of the industry in the country, as well as executives in the manufacturing and producing ends of the business. The commercial interests also are represented by associate membership in the Society.

The Society holds two conventions a year, one in the spring and one in the fall, the meetings being generally of four days' duration each, and being held at various places. At these meetings papers are presented and discussed on various phases of the industry, theoretical, technical, and practical. Demonstrations of new equipment and methods are also often given. A wide range of subjects is covered, and many of the authors are the highest authorities in their distinctive lines.

The papers presented at the convention together with the full discussions are printed as Transactions after each meeting. These Transactions form the most complete technical library in existence of the motion picture industry. They are sent to each member of the Society and may be obtained by non-members at a very nominal sum,

From the Hon. Secretary:

L. C. PORTER,

5th & Sussex Streets

TRANSACTIONS
OF THE
SOCIETY OF
MOTION PICTURE
ENGINEERS



Volume XI, Number 31

MEETING OF SEPTEMBER 26, 27, 28, 29, 1927

LAKE PLACID, N. Y.

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PRESIDENTIAL ADDRESS

FELLOW MEMBERS AND GUESTS:

IT GIVES me great pleasure to welcome you all to another annual convention of the Society, with such delightful surroundings and with such a promising program. As I look back over nearly ten years, during which I have been a member of the Society, I share with you in the pride and satisfaction in its growth, progress and accomplishments.

Most of the significant inventions and developments in our industry during the past decade have been announced or demonstrated at our conventions. Our Society has become the recognized authority for the reference of any questions pertaining to our industry and our TRANSACTIONS have an international reputation as the greatest contribution to its technical literature.

Our material and financial condition has kept pace with our scientific progress, so that the financial problems which formerly caused us much anxiety have been practically eliminated.

In looking over the former executive addresses, one is strongly impressed with the number of recommended changes in the administrative department of the Society. As a result of the changes which were made in accordance with the recommendations, the Society's business is now administered much more simply and I believe effectively by your Board of Governors than it was formerly conducted in open meeting with consequent confusion and loss of time during our conventions, which are now more profitably employed in the presentation and discussion of the valuable papers which are contributed on these occasions.

Probably few of the members who have not participated directly therein, realize the great amount of work which is undertaken and successfully accomplished by a few individuals who make up the committees and members of the Board of Governors.

Four years ago, we had 25 different committees functioning with more or less activity in our Society. Today, as much or perhaps more work is being accomplished by six committees. This of course means that the members of the present committees are devoting a larger proportion of their time and energy to the Society's business. This committee work has been facilitated to a considerable extent by the continuation on the various committees of men who have had several

years of experience in their respective capacities and have, therefore, acquired the ability to handle the work with a maximum of efficiency. It is only because of this familiarity with the duties as your executive that I felt justified in accepting the nomination for a third term as president, although two of my predecessors had each held a third term as your executive.

About 80 firms or organizations have membership in the Society of Motion Picture Engineers, and we may with confidence assert that we are fairly representative of the technical part of the motion picture industry. As a result, there is hardly a department of the industry that is not benefited by the activities of our Society. However, this is not as well known as it should be, and in spite of its importance, the Society is numerically small and comparatively unknown to a large number of people who are eligible for membership and who would be benefited thereby.

We are not in urgent need of increased membership, but we welcome new members who are in sympathy with the objects for which this Society was formed. The activities of the Society are wide in scope, and we are very liberal in our requirements for membership in our organization. With all this in mind, I earnestly request all members of our organization to do whatever they can to have the industry as a whole realize what we are doing. Speak a good word for the Society of Motion Picture Engineers whenever you can and assist in every possible way to show the entire industry why this organization should receive their full support. We wish the attendance at our meetings to be as large as possible, and we feel that every organization that sends a representative to attend our conventions will be well repaid.

In conclusion, let me extend my sincere appreciation to every member whose efforts have contributed to our success, to the organizations who have extended their support, and to the press and trade papers who have given us publicity.

* Kodascope Libraries, Inc., New York, N. Y.

PROGRESS IN THE MOTION PICTURE INDUSTRY

September, 1927 Report of the Progress Committee

Introduction

PERHAPS the most striking occurrence since the last meeting of the Society, one which has affected the entire industry and which promises to leave a permanent impression, is the wave of economy that struck the motion picture studios late last spring. Appearing first in the form of threatened salary cuts¹ which met with furious opposition from those affected, it rebounded and swept over the managements and their production practices: Criticism of the wasteful production methods in vogue was incited and various methods of reducing costs were discussed. At a meeting of the Academy of Motion Picture Arts and Sciences a comprehensive agreement was reached, involving producers, writers, directors, actors, and all other studio workers, whereby it is expected that a noticeable decrease in studio costs will be evidenced.²

In connection with the problem of reducing production costs, several of the large studios have been experimenting with incandescent lighting to replace arcs for general and special lighting effects. These experiments have met with marked success, as a result of which incandescent lamps are already extensively used.³ This method of lighting, comparatively new to the motion picture industry, promises not only to bring about a saving in operating costs of from 25 to 75% over the old,^{3,4} but also, when used with panchromatic film, gives better color rendition and eliminates the necessity for special make-up.

Respectfully submitted,

CARL E. EGELER, *Chairman*

A. S. HOWELL	J. I. CRABTREE
WM. V. D. KELLY	R. P. DEVAULT
J. H. KURLANDER	CARL L. GREGORY
ROWLAND ROGERS	KENNETH HICKMAN

Amateur Cinematography

A new amateur motion picture camera of the upright type, called the Cine Nizo 16, with one film magazine above the other, may be either driven by its motor or cranked by hand. The cranking speed can be 16, 8, or 1 picture per second, depending upon the point of application of the crank.⁵

Directions have been given for constructing a trick apparatus for the amateur to use in making animated drawings together with working plans of the equipment, which includes a sturdy table, a support for the sketches, a staging for the camera, and suitable lighting facilities.⁶

An American manufacturer has made available a 16 mm. camera with the $f/1.9$ lens; thus it may be used for photography under adverse light conditions.⁷

Cameras

No new cameras of radically different design have been introduced recently, but some minor improvements have been noted which make them easier to use and applicable to more adverse conditions.

A device of the finder type has been marketed which is said to ascertain correctly the field and angle of a picture to be taken, indicating what focal length lens to use, the exact proportion or dimensions of the subject to be photographed, and the photographic relation of colors and tones in the subject.⁸

The mechanism of a new gyroscopic camera tripod may be controlled with one hand. It is fitted with a locking arrangement which locks or releases instantaneously by a half turn of a knob and which gives absolute rigidity.⁹

Announcement has been made of another improvement which may be adapted to any camera; a device which permits altering of focal length without losing any frames or interrupting the continuity of exposure.¹⁰

A new speed camera capable of taking 2600 pictures per second has been designed to study the exact character of flashes occurring in generators and other electrical machines.¹¹ A new portable, spring-driven camera holds 200 feet of film and is capable of exposing 120 to 150 feet at one winding.¹²

A patent has been issued on a hand-held motion picture camera having a curved gate.¹³

Colored Motion Pictures

Much patent activity is still evidenced in the field of colored motion picture photography. Some of the more important patents are briefly described below.

Color record component images for additive or subtractive color cinematography may be produced by selective projection printing

from a multicolor record image taken on film provided with a screen of lenticular or linear refracting elements.¹⁴ Sensitive material for making these multicolor records is produced by rolling the film under the influence of heat with an engraved cylinder, which covers the rear surface of the support with minute refracting elements.¹⁵ Film thus embossed with microscopic linear refracting elements is employed in conjunction with a lens filter to produce objects in natural colors. A plate or cylinder whose surface is engraved with linear grooves numbering 12 to 35 per millimeter and of any desired shape of cross section has been patented.¹⁶

A patent has been granted upon a method of color photography in which two films are employed having colors arranged so that the color of the action in front of the background should be a color not complementary to the other picture; that is, the action might be red, and the background blue.¹⁷

Multicolor pictures visible by reflection or transmission may be obtained by forming a two layer screen, one layer having elements which are weakly colored compared with those in the second layer. The first layer may be a celluloid film, and the second a gelatin coating which is formed with screen elements by means of dyes which penetrate and color the film.¹⁸

The optical density gradations in the highlight portions of dye-absorbent photographic film are made more gradual than those of the half tone portions in order to accurately reproduce the details of the scene.¹⁹ The densities in the shadow portions are made at least as great as those in the half tone portions.²⁰

A new camera for color photography has four glass prisms of small angle slope to 90° apexes meeting concentrically at the axis of a large objective lens. With filters over the prism sections, four color separation negatives are obtained, and from these, positives, which may be combined by projection through a similar apparatus.²¹

A description has been given of the two-color additive processes of Pilny, Wolff-Heide, and Friese-Greene. The Pilny process places the red and green filter images side by side in the space of one frame on 35 mm. film, the images being turned at right angles to their usual directions by a prism in the camera. Wolff-Heide and Friese-Greene take the two color records in alternation on the film, the negative being coated with an orange filter over alternate frames. The pictures on the positive are dyed red and green alternately by means of a protective coating of varnish.²²

Education

A twelve year trial of education films has been made by the U. S. Department of Agriculture. During this period, over three hundred subjects were produced, of which two hundred and thirty are now in circulation. It has been concluded from this experience that educational films are extremely effective and that the field contains enormous possibilities which may exceed those of the use of film for entertainment.²³ It is said that too many tests of the educational value of motion pictures have been judged by the student's ability to pass certain examinations, and it is claimed that this is not a true measure of the worth of the films; other tests have proved their value in broadening experience and stimulating interest.²⁴ The motion picture may not always prove to be the most effective way of presenting ideas, but it has its own application which cannot be duplicated by any other means. In this connection it has been recommended that films be adapted to, but preferably subordinated to, the regular school curriculum.²⁵

The educational application of pictures may fail if applied by enthusiasts with no regard to the special technic necessary. This problem has been studied and recommendations given. Accessibility and applicability of pictures, their availability at all times when needed, and a satisfactory means of projection are all important factors which must be considered carefully.²⁶

Many schools will have their first taste of educational motion pictures this fall, and much valuable information and experience will undoubtedly be obtained during the next year. Pictures will be used in the Denver grade schools in the study of geography; health and hygiene, civics, fine and practical arts, and general science.²⁷

A cinematographic program of education is being tentatively introduced into many English schools, but there is a scarcity of adequate film. Suggestions have been made relative to the future choice, preparations, and application of film in this connection. A report of a review of film made for the League of Nations Union and used for a series of history lessons in the upper classes of elementary schools favors the use of such film.²⁸ Films relating to agriculture, hygiene, etc., have been produced in France and successfully applied to teaching.²⁹

Further progress is noted in the problem of education within the industry. The motion picture theater owners of the northwest have established a projection school at the Dunwoody Institute at St. Paul.³⁰

Films and Emulsions

Film suitable for making duplicate negatives should have a higher resolving power than ordinary negative to keep graininess at a minimum, and should have a lower maximum contrast than motion picture positives to permit complete development. Such a film has been produced.³¹ Some additional experiments have been made to determine the resolving power of photographic materials, and the results obtained show a large variation, depending upon the ratio, in a parallel line test object, of width of the line to the space. For the range investigated, a linear relationship exists between the resolving power and the logarithm of this ratio.³²

The causes of graininess in motion picture film and practical recommendations for reducing this graininess to a minimum were discussed in a paper presented before the last meeting of this society. Graininess depends upon the density of the silver deposit, the nature of the emulsion, the exposure, the time which elapses between exposure and development, the nature of the developer, the degree of development, and the conditions during drying.³³ An analysis has been made of the economic and photographic advantages of various reversal processes, and it is remarked that the reversal process gives finer grained images than the ordinary printing process.³⁴

It is claimed that brightness in color and permanence in tone result from treating film, thoroughly washed after fixation, with a mordant bath of potassium ferricyanide, ammonium bichromate, and sulfuric acid in a water solution, and then applying a basic dye to the mordanted image.³⁵

A chromate film of higher sensitivity may be produced by treating unhardened gelatin-coated film with a special bichromate-ferricyanide-bromide solution. Films thus treated were said to have been printed at 113 to 240 meters per hour. However, attempts by others to apply the method have been unsuccessful.³⁶

Cellulose materials can be made more reactive toward acetylation or other esterification by pre-treatment with the vapors of lower fatty acids, such as acetic or formic acids or mixtures of these in an admixture of air or other indifferent gases or vapors.³⁷

The difference between the reducing power of metoquinine and that of the mixture of methyl paraminophenol and hydroquinine are discussed in a reply to a paper of Hubl who disagreed with the opinions of Lumière and Seyewetz on this subject.³⁸

Experiments have been made which show that the solubilities of the silver halides in hypo have been stated too high owing to the adoption of conditions favoring supersaturation. It is concluded that when the silver content of a 10% bath exceeds 0.6–0.7%, it becomes impossible to completely remove the silver salt by washing.³⁹

The importance of halation on motion picture film has been discussed. Halation is of two kinds: diffusion halation, due to the diffusion of light by a turbid emulsion; and reflection halation, caused by light transmitted through the emulsion and then reflected by one or the other surfaces of the film base. Non-halation film solves the difficulty by giving non-reflecting surfaces on the film.⁴⁰

The relation between the specular and the diffuse photographic densities were discussed in a recent paper. A formula was theoretically derived which correlates the so-called specular and diffuse density of a layer of light-scattering medium, such as a developed photographic film or plate.⁴¹

A patent has been issued on the manufacture of cellulose acetates or other esters of cellulose by a dry process. The cellulose employed as the starting material is pre-treated with organic carboxylic acids in the absence of solvents, and the reaction is performed by passing over or through the pretreated materials the vapors of acetic anhydride or other esterifying agent either alone or in admixture with air.⁴²

A British patent was granted on a substitute for celluloid as the support of the sensitive layer, produced by impregnating paper with a solution of artificial resin in alcohol.⁴³ A French patent was issued on a process of embodying silk threads in the edges of motion picture film during manufacture.⁴⁴

Safety film must be as nearly chemically inert in relation to its sensitive coating as is nitrate base; its coefficient of expansion must not greatly exceed that of the nitrate base, and it must have uniform strength and retain its characteristics over a period of months.⁴⁵ The inflammability of nitrate film may be reduced by the introduction of cellulose phosphate;—cellulose can be satisfactorily nitrated by mixtures in which the sulfuric acid ordinarily employed is replaced by phosphoric acid.⁴⁶

In order to determine the strength of film splices, a series of tests were made on both fresh and old film with a number of different cements. Results of the tests were tabulated with the compositions of the various cements used.⁴⁷

General

Most modern movie palaces present a program which is a combination of motion pictures and vaudeville or specialties, requiring effects of "atmosphere" similar to those used in the legitimate theater. These are produced by so-called effect lighting, of which there are three different divisions: the projection of animated scenic effects; of colored effects; and of simple masks, cutouts, and special lantern slides. A very comprehensive paper dealing with this subject was presented at the last meeting of the Society, in which a description was given of the various lighting effects together with the methods and apparatus used.⁴⁸

An organization known as the Academy of Motion Picture Arts and Sciences has been formed in Hollywood and is composed of directors, writers, producers, actors, and technicians. It has the purpose of securing constructive coöperation among its members and the advancement of the industry through the exchange of ideas. Scholarships will be given to assist persons working on improvements in the making of motion pictures, and a building is to be erected which will house a laboratory and a theater.⁴⁹

The eighth annual convention of the Motion Picture Theater Owners of America held in Columbus, Ohio, was characterized by a spirit of harmony and coöperation. Every effort was made to make the body truly representative of the industry, thus widening its scope and increasing its possibilities of service.⁵⁰

A speed record was established in bringing to New York pictures of Lindbergh's reception at Washington. A special train equipped with a rolling laboratory in which the film was developed, printed, edited enroute, made the two hundred twenty six miles from Washington to New York in one hundred eighty-seven minutes. The films were shown in a leading Broadway theater ten minutes after the train arrived in the station.⁵¹

A new process has been patented whereby tragic and comic or any two pictures may be projected simultaneously, the spectators selecting for viewing the one which interests them most. Two different colored images are produced on opposite sides of the film, which when looked at through suitable color screens permit viewing either image.⁵²

A large steamship line now offers the attraction of motion pictures on shipboard. Portable apparatus has been installed, and the pictures are shown either on deck or in the saloon. The booth may be thrown overboard in case of a serious fire.⁵³

A device patented in Germany is said to permit the taking of 48,000 exposures per second. Such an apparatus will have a large field of application in scientific and experimental work.⁵⁴

A paper presented before a recent meeting of the Society calls attention to the many ways in which the National Bureau of Standards may be of service to those working on technical motion picture problems.⁵⁵

The handling of motion picture films under different climatic conditions, the transportation difficulties, and the manipulations and processing of film under arctic and tropical conditions have been discussed in a recent paper. Detailed description is given of the equipment and manner of working.⁵⁶

Holland now has a motion picture studio located at Rotterdam said to be fully equipped to make large productions.⁵⁷ Two Zeppelin hangars at Staaken, Germany, have been made over into modern studios.⁵⁸

The Eastman Kodak Company has inaugurated a four-minute reel series of pictures featuring well known actors and actresses. New subjects are to be issued monthly, so the amateur may build up a library of those he desires.⁵⁹

France is making up films showing the history of its various provinces and part of each film is colored. Particular attention is being paid to the preservation of the film.⁶⁰

A practical digest of the year's work in photography is given in an extensive résumé containing 230 references,⁶¹ and another historical résumé covers the development of the technic of motion picture projection.⁶²

Illuminants and Lighting

While nothing fundamentally new has been introduced recently in the field of illuminants, constant progress is being toward the improvement of various types of light sources and in the improvement of light control equipment.

Recent developments in high wattage incandescent lamps together with the increasing adoption of panchromatic film is leading to a widespread use of incandescent lamps in the motion picture studio.⁶³ Illuminating engineers from the east have been in the Los Angeles territory during the past summer coöperating with several of the large studios there in determining the correct types and wattages of lamps to be used and assisting in the selection and design of the proper light control equipment.^{3,64}

In a paper recently presented before the Society, the requirements of studio lighting are discussed, and the advantages of incandescent lighting are given with a cost analysis of the use of various types of light sources in conjunction with orthochromatic and panchromatic film. It is concluded that the desirable quality of the light and the convenient operating characteristics of incandescent lamps are large factors in determining whether these will be used to replace other types of light sources in lighting the motion picture set.⁶⁵

A polygonal floodlighting mirror is described in a paper presented at the last meeting of the Society. The disadvantages are pointed out of refocusing the regular high intensity arc searchlight with the parabolic mirror to get a wider beam spread, and it is demonstrated that the use of a polygonal mirror is a more suitable arrangement. The method of computing the dimensions of the polygons is given as well as a photometric comparison of the two types of reflectors.⁶⁶

A new light source for Mazda projector lamps was described in another paper given at the last meeting of the Society. It is known as the coiled-coil filament source and consists of a single coil type of filament similar to that commonly used, coiled again to give a much higher degree of concentration. Its chief advantage is the higher screen illumination obtainable as a result of the smaller source size especially for lamps of the 115-volt class. It is at present applicable only to the lower wattage lamps, such as those used in the 16-millimeter film projector field.⁶⁷

A high intensity reflector arc lamp was recently demonstrated at Chicago. The practical problems involved in the construction of this equipment are the design of mechanical arrangements for the proper feeding of the carbons, regular burning of the crater, mirror location, and a reduction of the heat at the aperture. The problem of cooling is very important; this particular device accomplishes it by means of a motor driven fan which forces a stream of cool air past the film. To protect the glass mirror, a disc of heat-resisting glass is placed between it and the arc, and another air line from the fan directs a blast between this heat resisting glass and the mirror.⁶⁸ Another reflector arc has been placed on the market.⁶⁹

It is suggested that the Coolidge tube has possibilities as a projection light source. To employ it, the film might be backed with a mineral coating, or a suitable mineral surface could be arranged behind the gate to receive the bombardment of the electron stream.⁷⁰

Laboratory Methods and Equipment

It is necessary that motion picture film be cleaned at various stages in its progress from the laboratory to the theater and also after its use. A mixture of ammonia, water, and alcohol is satisfactory for cleaning the base side of the negative or positive film. To remove dust and finger markings from negatives before printing, wiping with silk plush moistened with pure carbon tetrachloride is recommended. The flexibility may be restored by passing it through a bath containing a mixture of water and alcohol.⁷¹

A pneumatic film squeegee has been developed for use in the laboratory to remove excess moisture after washing, before drying. A 25% saving of time is effected through the use of the air squeegee and subsequent polishing of the film is unnecessary.⁷²

A method of impregnating wood with paraffin has greatly increased the value of wooden tanks for photographic solutions. Spruce so treated was found to withstand the action of acid and alkaline solutions with a minimum of absorption and consequent swelling.⁷³

Trioxymethylene in the presence of sodium sulphite can be used to replace the alkali in the preparation of various phenolic developers. A fixing bath is recommended for photographic papers which employs trioxymethylene instead of alum as the hardening constituent. This is more stable than an acid-alum bath.⁷⁴

Lenses

An anastigmat lens said to be three times as fast as the $f/2.7$ has been placed on the market. It is claimed to give improved perspective, the finest delineation and modeling, to be free from focal differences with the various stops, and to have complete correction for all colors of the spectrum.⁷⁵

A patent has been granted on a projection lens having a short back focus, permitting the lens to be placed close to the gate. The focal length of the front component is equal to the sum of the focal length of the whole lens plus twice the back focal length. The components are separated by the focal length of the entire lens, which is the same as the focal length of the rear compartment.⁷⁶

A seven-piece objective lens working at $f/1$ has been patented. Three of its seven elements are cemented together.⁷⁷

New Applications

X-ray motion pictures have been successfully made in England. The motion picture section of the Trade Commission in Paris reports that motion pictures of the hand, foot, and knee in motion, clearly showing bone movements, and of the chest showing the beating of the heart and movement of the ribs in the process of breathing were displayed before an educational body at the International Studio at Elstree, England.⁷⁸

An apparatus for taking motion pictures of surgical operations has been patented which fulfills the conditions for asepsis. The camera is suspended from the ceiling and is controlled by motors outside of the room; it takes a view that portrays the details and is said not to require lighting harmful to the patient or operators.⁷⁹

Slow motion botanical studies may be made with a motion picture camera having its exposure mechanism actuated by a clockwork motor, thus making single exposures at any predetermined intervals of a half minute to two hours.⁸⁰

The motion picture camera has been used to determine the melting point and record the liquefaction of graphite in the electric furnace.⁸¹

Latest progress in the field of micro-cinematography is covered in a recent description of various devices used in this work. A camera having an auxiliary shutter between the lamp and the microscope is focussed from the rear through the film.⁸²

A battery of four single exposure motion picture cameras were installed in a county court house to make photographic records. The cameras were suspended vertically over the records to be photographed, and exposures were made by means of foot pedals; 40,000 pages could be daily copied.⁸³ The French have also made use of films in court. The details of a daring gem robbery were reconstructed and filmed, and the picture was shown for the benefit of the courtroom at the trial. This is said to be the first time that motion pictures have been used in court for the application of justice.⁸⁴

Physiology

Some further experiments have been made to determine the effect of the motion picture upon the human eye. It has been reported that more eye fatigue was caused by 45 minutes' reading than by viewing black and white motion pictures for a period of one and a half hours.

In fact, after a group had been reading for 45 minutes and showed a loss in acuity of vision, they immediately viewed a picture for an hour and a half and demonstrated a gain in acuity. Therefore, it is recommended that if your brain and eyes are tired, "go to the movies." These experiments indicated in some instances a greater loss in acuity after viewing black and white pictures than after viewing colored pictures.⁸⁵

Projectors

A new low-priced professional projector has been placed on the market in which is embodied everything in efficiency and construction that is found in more expensive types. Designed for a theater or hall of 1000 seats or less, it is equipped with a Mazda lamp and has been used to project a 16-foot picture at distances up to 135 feet.⁸⁶

A new gate mechanism has been developed for one of the leading makes of projectors now on the market. The chief feature of this new device is the fact that it is less affected by the high aperture temperatures of mirror and high intensity arc light sources. The mechanism consists of three heavy plates, a heavy grid iron plate facing the light source, another mounted upon and back of it which carries the gate latch, upper film shield and idler roller, and a steel plate which carries the tension shoes and springs.⁸⁷

A patent has been granted on a motion picture projector having an adjustable optical system adapting it for use with either ordinary films or films having separated color component images requiring separate optical paths.⁸⁸ Another patent covers a motion picture projector which has two motion heads alternately illuminated by one light source. It is claimed that substantially the whole of the light is utilized during its transference from one head to the other.⁸⁹

An improved cinematograph projector has been described in which an epicyclic gear drives the maltese cross and intermittent sprocket, thus increasing the operating speed.⁹⁰

A dissolving stereopticon using the reflector arc principle consists of an 8-inch parabolic mirror which intercepts the light from the usual horizontal carbon, directing it through two 5-inch diameter condensers, giving two beams for a side-by-side slide projection.⁹¹

A careful study has been made of the factors relating to the dimensions of sprockets for motion picture apparatus in view of their standardization, and the correct sprocket diameters for films of various shrinkages were determined.⁹²

Statistics

Approximately \$1,500,000,000 are invested in the motion picture industry, \$1,250,000,000 of which are invested in theaters, the balance in studios and distributing offices.⁹³

Imports and exports of motion picture film of the United States, Germany, England, and France, have been given in a summary which covers the last three years.⁹⁴ A report of the United States Department of Commerce shows a decrease in exports of motion picture film for the year 1926.⁹⁵ The export of unexposed film from Germany to the United States decreased from 26,062,800 kilograms in 1925 to 15,692,300 kilograms in 1926. Export of other films increased from 58,500 kilograms to 100,600.⁹⁶

The South American market strongly favors United States films, 90% of the pictures shown there being made in the United States.⁹⁷

A report has been made which gives the industry's income for 1925. In this year, 5,376 amusement corporations and 314 motion picture producers filed returns with the Government showing their assets in cash, accounts receivable, notes receivable, inventory, fixed property and investments, and their liabilities in accounts payable, notes payable, bonded debt, and mortgages.⁹⁸

A survey has been made of the producing organizations and of the distribution and exhibition conditions in Europe and England.⁹⁹ It has been reported to the Department of Commerce that in metropolitan France 3,995 motion picture theaters are registered, 180 of which are in Paris. Twenty-four of the Parisian theaters have more than 1500 seats.¹⁰⁰ There are approximately 9500 theaters in Central Europe, Spain, and Italy. Germany, the largest motion picture market in Europe, had at the beginning of 1926, 3878 theaters. In Germany, 206 producers made 246 pictures that year.¹⁰¹ Belgium has, according to another survey 1000 theaters, 100 of which are in Brussels.¹⁰²

Australia has one picture house for each 5000 of population,¹⁰³ while 900,000,000 people in the Orient are served by 1600 theaters. Japanese producers make approximately 700 features yearly.¹⁰⁴

Stereoscopic Motion Pictures

A large producing organization has acquired the rights to a process of making third dimension pictures, developed by two Swiss inventors. No auxiliary apparatus is required to project films made by this process; standard theater projectors are used, and the pictures

are viewed with the unaided eye.¹⁰⁵ A film has been completed which is said to have met all expectations.¹⁰⁶

A patent has been issued upon another means of stereoscopic projection which employs two screens placed at opposite ends of a hall. The spectators can see directly only one screen and are provided with a viewing means which enables them to register the two sets of images.¹⁰⁷

It is said that a stereoscopic illusion is attained through the use of the so-called "magnascope." Another feature of this device is that a picture 30×49 feet in size may be projected.¹⁰⁸

A motion picture screen composed of small glass particles has been installed in a New York theater and is said to give an illusion of depth with ordinary projection.¹⁰⁹

In an amusement park in Berlin, still and motion pictures have been projected on a curtain of spray from jets of water, giving an illusion of relief.¹¹⁰

Talking Motion Pictures

A new device for projecting talking pictures is called the Fil-mophone. A selenium cell is used to convert the light to electrical energy; the film can register oscillations of a frequency of 10,000.¹¹¹

The Photophone is to be sold direct to theaters. Concentration of effort will be directed upon music scores for accompanying films. Synchronized scores will be made for features from all companies who will coöperate to the extent of furnishing a print for screening. Thus, even the smallest of theaters may have excellent musical entertainment with their pictures.¹¹²

Two other sound synchronization devices about to be made available are the Vocafilm¹¹³ and the Orchestraphone. The Orchestraphone is designed primarily for small theaters and was recently given a trial in a Chicago theater.¹¹⁴

The effect of the spreading of the image due to irradiation on the sound record in the case of talking films has been reported.¹¹⁵

In Vitaphone productions, the synchronization of sound recording and picture taking is constantly checked by a stroboscopic apparatus employing a sector disc and a Neon tube. A loud speaker is also used in the recording room to check the quality of electrical "sound" fluctuations.¹¹⁶

Trick Cinematography

An interesting paper was presented before the last meeting of the Society describing various methods of obtaining illusions in cinematography. The different technical, artistic, and dramatic problems

involved in the production of four different effects or scenes were discussed and a description given of the methods used.¹¹⁷ In another paper presented at this meeting a résumé was given of various patents which have been issued on methods of trick photography.¹¹⁸

Fifteen methods of trick photography have been described to illustrate how the cinematographer analyzes motions in two or more directions. Reverse camera, glass work, double exposure, one picture turn, decreasing the taking speed, slow motion photography, stop camera and substitute, fade in and fade out, double printing, double exposure by use of mirrors, projection printing, and the use of mechanical devices are among the methods described.¹¹⁹

A method of trick photography known as the Schuefftan combination process has been patented. A mirror having the silver backing removed locally is placed in the field of the camera, and part of the scene painted in miniature is taken by reflection in the mirror. The images are made to blend into each other by vignetting the clear opening in the mirror.^{120,121,122} This process has proved useful for many kinds of motion picture work, including color cinematography.¹²³ Further applications of the process have been enumerated. The relative sizes of objects can be changed by placing them at different distances. A collecting lens is used on the other side of the mirror to bring both objects into focus in the camera, and with a combination of several mirrors the size of the vignettted exposure aperture hole may be varied during the action.¹²⁴

Another new process has been described in which action taken on one location may be superimposed with complete naturalness on scenes which were made on another location.¹²⁵

Two other recent patents cover processes in which pictures are taken by the use of direct masks and masked reflectors in the field of view,¹²⁶ and a method is employed in which silhouettes are thrown on a transparent background.¹²⁷

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REPORT OF THE STANDARDS AND NOMENCLATURE COMMITTEE

September, 1927

Sprocket Dimensions

AT THE Norfolk meeting of the Society the sprocket dimensions in accordance with the general plan of Mr. J. G. Jones had first approval as follows:

The take-up sprocket, which is a hold back sprocket on a motion picture projector, should be designed to have the same pitch as the perforations on film which has shrunk to the maximum amount occurring with films in commercially useful condition as supplied by exchanges.

The feed and intermittent sprockets are to have a pitch equal to that of the sprocket holes in newly finished film.

The Committee finds that the maximum shrinkage of useful film is 1.5% and recommends a take-up sprocket designed accordingly. The shrinkage of newly processed film, for which the feed and intermittent are designed, is 0.13%. These latter sprockets, as has already been shown, will accommodate film shrunk as much as 2.92% without damage. Dimensions of sprockets to produce these results are illustrated in Charts A, B, and C. (pp. 407, 408 in No. 29 Transactions.)

The essential dimensions are:

<i>For take-up sprocket</i>	Base diameter 0.9321 in. (23.67 mm.) tooth 0.050 in. (1.26 mm.)
<i>For feed and intermittent</i>	Base diameter 0.9452 in. (24.01 mm.) tooth 0.050 in. (1.26 mm.)

All other dimensions are shown on Chart B.

Discussion

DR. GAGE: I wish to place the matter of sprocket dimensions before the Society for second approval.

DR. MEES: In regard to the shape of the perforation, I am not making a motion but bringing the matter to the attention of the Committee. The shape adopted by the International Congress is that either the Kodak square perforation with rounded corners or the Pathé perforation should be adopted. This was adopted at Paris after a great deal of discussion. Since that time there has been an amalgamation of the Pathé and Kodak Companies in France, and I think possibly the Pathé perforation may disappear. This must be discussed with the French people, but I wonder whether it is wise to

go to the committee with this dimension in view of the fact that it may be obsolete when it gets there. I suggest that it might be well to hold this particular thing up for six months to see what happens. If the French users object, of course, there will be no change.

PRESIDENT COOK: It seems to me, Dr. Mees, in the first place that the point raised is out of order because the standard has already been adopted. We cannot, without a reopening of the entire matter, do anything; it would necessitate a further delay of six months to reopen it. If I understand you correctly, it will become obsolete automatically and therefore disappear without any particular legislation about it.

DR. MEES: But you are taking this to the American Engineering Standards Committee and that is an authoritative body. It seems to me that it is a pity for us to put up to the committee something which is obsolete. If you have a rule which insists on your taking something adopted a year ago, it is unfortunate.

With regard to the shrinkage between sprockets, I do not know what Mr. Jones has done since the last meeting, but I called his attention to a paper by Joachim published in the TRANSACTIONS that did not accept Mr. Jones' standard. Joachim said that shrinkage dimensions of $1\frac{1}{2}\%$ did not make the best sprocket, and I wondered if the Committee had considered this. I suppose Dr. Gage and Mr. Jones have gone over this, in which case I move that we adopt the motion.

DR. GAGE: Mr. Jones' recommendations are in agreement with Joachim's discussion. Mr. Jones' original proposals are given in No. 30 TRANSACTIONS. That was the recommendation which the standard must involve—the basic principles. Originally, Mr. Jones designed the take-up sprocket for a maximum shrinkage of 2.92%, as given in the previous TRANSACTIONS (No. 27). Your Committee found from all the information we could get hold of that the maximum shrinkage to design for was $1\frac{1}{2}\%$, and this is embodied in the recommendations.

PRESIDENT COOK: It would seem from the discussion that the Joachim report was given careful consideration by Mr. Jones at the time, and it was published as one of the few things included in the TRANSACTIONS which are not of our own origin because it was felt it was of such importance. The matter has been up several times and was finally adopted after much discussion at Norfolk. I realize that these matters must not be passed on hastily, but I think the matter

has been carefully considered and discussed, and I believe the recommendation is the best that can be made.

DR. GAGE: The recommendation of the Paris Congress has been given very careful consideration by the members of this committee. The subject has been placed before the Society, as is evidenced by Charts IV. and V. (No. 30 TRANSACTIONS, pp. 409-10) together with their captions. Mr. John Jones took up the matter with Mr. Vinton in England, and the charts discussing the Paris dimensions—photostats of these same charts—were sent over and the thing discussed in detail, so that you can assure them it was given very careful consideration by the Society. The reason we adopted what we did was that the recommendations of the Congress were not workable and would destroy film, and the American standard in actual use and as given by Chart B passes film with the minimum injury.

PRESIDENT COOK: If I understand correctly, our standard will run any film without damage, whereas the Paris standard is open to the criticism that badly shrunken film might be injured by running on a sprocket similar to theirs.

(Motion carried to adopt above recommendations.)

Camera and Projector Speeds

In the discussion of camera cranking speed it was pointed out that with speaking movies where the speech is on one edge of the film, it is necessary to change the dimensions of the aperture and to have the standard of projection speed and taking speed exactly the same. For this reason your chairman sent a circular letter to several manufacturers of talking movies asking for details regarding the taking and projection speed which they had adopted. The replies are summarized in the following table:

<i>Name of Firm</i>	<i>Taking Speed</i>	<i>Projection Speed</i>
Bell Telephone Laboratories	90 ft. per min.	90 ft. per min.
Radio Corp. of America	85 ft. per min.	85 ft. per min.
Fox-Case Corp. (Movietone)	90 ft. per min.	90 ft. per min.
DeForest (Phonofilm)	80 ft. per min.	80 ft. per min.
Westinghouse Electric & Mfg. Co.	85 ft. per min.	85 ft. per min.

With regard to projecture dimensions, DeForest uses an aperture $\frac{1}{61}$ inch narrower than the standard. The dimensions of the Fox-Case aperture are given in Fig. 3, page 1 No. 31, TRANSACTIONS. The other firms above have not established aperture dimensions.

Discussion

DR. MEES: With regard to the report as a whole, it seems to me that the Board of Governors and the Standards Committee should consider some more flexible method of procedure. I do not agree with Mr. Kintner's remarks that it is too early for standards to be formed. The earlier standards are laid down, the better. I think we should strengthen our Standards Committee and ask them to take more action than they have in the past—and they have not been lacking in this respect; and that we should possibly revise our procedure so that when we have made a mistake it is possible to change it. This matter of tying ourselves to errors appears to me to be a mistake. We are likely to make errors with new things. For instance, if somebody invented a new sprocket hole system at the present time it would be adopted by the manufacturers, and two years later it would be adopted by this body, which is foolish when things change as fast as they do now. We have grave problems in connection with standards; one is the talking film business. We have seen the mix-up we have got into on speeds for musical films. Incidentally, we are in trouble on all speeds. We have said there is to be an average speed of 60 feet per minute for cameras and 80 feet per minute for projection with normal presentation, which is not true, as we know. Of course, all that has arisen from the fact that the Maltese cross movement won't give a flickerless screen at 60 feet a minute, and the projectors have to be speeded up apart from the conflict between exhibitor and producer as to how much film should be shown in an hour. Now, when this is done, the taking speed should also be 80 feet per minute; the Society made the mistake of not asking the men to take at 80 when they were going to project at that speed. Through our *TRANSACTIONS*, the Western Electric Company have adopted a speed of 90 feet a minute, and the people who are starting to work with them find it necessary to project at this speed. We can't ask people now in production to adopt something different, and our speed of 80 feet a minute is obsolete anyway. None of the theaters are running under 90 feet, so that we may as well accept facts and acknowledge that the speeds were adopted in the days of our ignorance. In the case of sound reproduction, taking and projecting speeds must be the same. The General Electric adopted 85 feet a minute.

We come to the question of the gate for the talking movie, and that we must standardize. We have a regulation that the height

of the picture is to be three-quarters of the width. In the case of talking films, that is impossible, and there are other experimental films coming along in which the shape of the aperture will be different. The Society should take a hand at this point of the argument.

Then, the whole field of the amateur apparatus requires standardization very badly. It has been standardized as much as it has because the Eastman Kodak Company started making film for it and has standardized the film. The Society approved the 16 mm film size and should now adopt standards for gates and sprockets so that they fit the film. In the past, manufacturers have discussed the matter with the Kodak Company and they suggested what should be done so that the matter is not in chaos, but it will be very soon. The German manufacturers are starting in this field and others are also considering it.

I think the Standards Committee have a lot of work before them, and we must probably alter our methods. I do not think we can improve the personnel or willingness of the Committee, but I think we must strengthen it.

PRESIDENT COOK: With regard to standardization on certain features, we are delayed because of just such discussions as came up this morning.

DR. MEES: I am asking that the Standards Committee of the Society get ahead on the standardizing of new things as soon as they come out, so that other people will adopt them. If the speed of projection of musical film had been laid down at a meeting of the Society, then the Western Electric Company and others would have agreed, especially if they had had a letter from the committee.

MR. RICHARDSON: For the most part I regard what Dr. Mees has said as in every way excellent. The points he has raised are pertinent. For many years I have preached the gospel that camera and projector speed should be the same. I have been roundly abused and even ridiculed for doing so. When the matter first came before this Society I had many arguments with my colleagues on the Standards and Nomenclature Committee concerning the advisability of making a recommendation that camera or "taking" speed and projection speed be the same. I was over-ruled chiefly on the ground that inasmuch as to increase taking speed to the relatively high projection speed made necessary by the demand for high screen illumination would compel the use of much more negative film, hence producers would not adopt the recommendation even though it be made. The chief function of this Society is to determine what is the

correct practice and to establish that finding as a recommended practice or standard. If the manufacturer does not wish to follow correct practice, it is no concern of this Society.

MR. CUFFE: I don't think adopting a particular projection speed will help much; camera speeds vary. You can go out on any set and find a speed from 10 up to a great speed. When a director gets his picture in the cutting room, he cuts for a certain projection speed. There are not two directors cutting for the same speed. If the picture is projected slower than that speed for which he cuts, it will drag. Griffith cuts his pictures to waltz tempo and another director will cut to a speed of 100 feet, and when run at a speed less than this, the action will drag on the screen; another will cut to 85 feet.

MR. RICHARDSON: On what do they base this?

MR. CUFFE: On the temperamental inclination of the director.

PRESIDENT COOK: We all realize that a standard taking and projecting speed is not possible because it is under the control of the cameraman and director, and the most we can hope for is recommended practice. Standards adopted are very easily susceptible to revision and amendment, and Mr. Schlink of the American Engineering Standards Committee pointed out that it was not desirable to delay adoption of a standard because it was to be changed later. Most of the time of their committee is taken up with changes which are desirable. The procedure for revision is far simpler than for original adoption, and on that account the Standards Committee urged the adoption of standards even tentatively in an effort to clarify features of the industry with the idea that with progress they can be revised to suit new conditions.

MR. STEWART: No matter what we agree to be standards, there are bound to be certain objections. A film is being made of 16 mm. width mounted on a thin brass base having a 28 mm. sprocket hole.

PRESIDENT COOK: That would not detract from our making standards as fast as we can.

DR. GAGE: For the information of the Society I will say that Dr. Mees will get a letter from the Committee saying that any recommendation he has in mind be reduced to drawings for the TRANSACTIONS, and these will be presented at the next meeting to find out if the Society wishes to incorporate them as standard. The different manufacturers who sent us the information they did as to projection speeds, aperture dimensions, and so on will get a complete set of all the letters sent in to the Committee, so that they can think things

over and will get the suggestion that they get together and standardize something so that we can take it up at the next meeting.

PRESIDENT COOK: The Chair recommends to the Chairman of the Membership Committee that he make an effort to secure at least one representative member from each of the new talking movie companies—the General Electric and others—so that they may be represented not only in the membership but on the Standards Committee. The Chair will be pleased to appoint a representative member from each of these organizations on the Standards Committee in an effort to clarify standards of this new branch of talking movies.

DR. HICKMAN: The President's suggestion that members of leading firms be asked to join the Society for the purpose of coöperating with the Standards Committee shall be attended to immediately. We have circularized such men in the last few months but have received the same excuse in each case; namely, that they could not spare the money personally. Now it is my very strong feeling that such men should be made members of the Society by their parent firms, that it is in the interest of the firms to be represented, and that they should therefore pay the dues. I suggest that Dr. Gage write to the heads of departments of the big technical companies and put the matter before them.

A request for coöperation sent to English firms through Mr. Vinton received another rebuff, which you may agree was a just one. Mr. Vinton said that so long as our attitude towards the Standards proposed by other people at the Paris conference remained unsatisfactory, he would not feel justified in recommending membership to his co-workers. Surely, we should look into the matter and dispel such feelings.

PRESIDENT COOK: That is what Dr. Gage has done in the present instance. I think your suggestion is a good one—that the invitation to membership representatives in our Society would very properly come from the Chairman of the Standards Committee in his reply to those letters, so that we should start at the top, and they would delegate the member to come in. I suggest, Dr. Gage, that you recommend that one of their members join the Society for this purpose.

MR. BEGGS: I think the Standards Committee should be interested in different types of incandescent lamps for studio lighting to avoid disagreements on use. It is the same matter as would come before the American Railroad Association.

PRESIDENT COOK: I suggest that you write a letter to the Committee and place the matter before them.

AN EXHIBITOR'S PROBLEMS IN 1927

ERIC T. CLARKE*

FOR the year which has passed since I last addressed your body I have only one fundamental change in policy to report. All the rest of what I have to say today represents continued development of policies already in effect a year ago. This one change is the elimination of the split week and the adoption in its place of a double feature program.

For the benefit of those who are not familiar with the first-run picture situation in Rochester, I should explain that we run three first-run downtown picture houses: the Eastman, seating 3,350; the Piccadilly, seating 2,200; and the Regent, seating 1,800. It has for several years been our policy to buy blocks totaling some 200 pictures, securing these pictures on an interchangeable basis, so that upon screening they may be assigned to the house best suited to play them. I do not feel that it would be appropriate for me at this time to discuss the merits or demerits of block booking. The problems at present under consideration in connection with block booking do not apply to those who, like ourselves, need in the year more than 200 features for first-run showing in the same town.

For a city the size of Rochester it is clear that there will rarely, if ever, be more than 100 pictures in a season's output that are worthy of a week's run. In the spring, when the companies' projected output for the season is published, we cannot be sure just which pictures are going to be included in this hundred, but our experience has shown that where we have the choice of the entire season's product, the purchase in block of some 200 pictures will assure us of practically all the good ones which we naturally want.

The problem of what to do with the remainder has always been a hard one. Up to the end of 1926 we continued the policy of occasional split weeks. By "split weeks" I mean running one picture four days (Sunday to Wednesday) and another the three remaining days of the week. By introducing a split week once or twice a month in one or the other of our two smaller houses (taking care never to split both houses in the same week), we were able to keep playing close to release date. Good and poor quality pictures seem to come along about evenly all the time, and it is necessary to avoid the ac-

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cumulation of unplayed releases. Another argument lay in the fact that we were able to carry a pair of second-class pictures in a split week on the momentum of the house and would suffer the effect of loss of business when we were able to come back the next week with a stronger picture. Nevertheless, the problem of what to do with these clucks bothered me. I hated to give over a week or a half-week to a picture when I knew we would die. I always felt uncomfortable when setting in a comedy or other subject around a weak feature. A good comedy may strengthen the bill if the picture is good, but it will never save a weak feature. So there was always a tendency to make the second half of a split week a junk bill. For a while we tried deliberately shelving these pictures or salvaging part of the cost by sale to some lesser house in town, but one can quickly go broke doing that, particularly now that the distributors have found that for the millions invested in production there has been only a very small percentage of profit and in consequence have forced exhibitors all over the country to pay fat increases over last season's averages. Finding after careful analysis that only a few of our patrons would ever return to the same house during the same week, we decided to make bargain bills by putting two features on at the same time and running these for the entire week. It is unusual in our part of the country to have a double-feature-first-run policy, but I am so well convinced of the merit of the plan that we now devote the Piccadilly to nothing else. By taking care in the pairing of the features, we find a steadier patronage than we ever knew before. Even if the average customer does not enjoy one of the features, he will probably find satisfaction in the other. By this plan we have at least found a healthy outlet for the "westerns" which each company now insists on making and including in the general line. We continue a weekly film news to space the film apart, but all short subjects, both single and double reels, have been eliminated from our Piccadilly Theater. Whatever the argument for buying blocks of features in order to get the good ones, I can see no justification in our loading ourselves up with comedies beyond our actual requirements. For the present year, at any rate, the market is overstocked with comedies, and we are able to secure all the choice we wish. The average footage on the class of features I have been describing I have found from a checkup of over 40 pictures to be around 6,025, so we have adopted a two-hour and twenty-four minute schedule of five 13,000-foot complete shows in the daily operation.

In the Eastman Theater and Regent Theater I still stick to the two-hour show, and this brings me to the second question I wish to discuss and that is, namely, the relative importance of film and presentation. It is a live issue. The continuance of the policy of the two-hour show is only another way of saying that I side completely with those who look on the film as of first importance, and that I side against those who attempt to build an elaborate show that will overshadow the film.

The present craze for big spectacles, lavish presentations, costly stage bands is, as I see it, only a passing fad. Its origin however is interesting and is due to three conditions:

1. Vaudeville has had to come to pictures.

2. Large expensive houses tied to one line of product have felt the need of something to help carry those self-same weak sisters of which I have just spoken.

3. Imitation of Roxy and attempts to beat him at his own game.

Let us analyze these conditions:

After many years' success in their own field, the straight vaudeville theaters found themselves faced on the one hand with increased cost caused largely by higher transportation expense. On the other hand, their receipts were dwindling. The increase in movie attendance certainly took business away from the vaudeville houses. Inclusion of pictures in vaudeville programs resulted in consequence, enabling a satisfactory show to be given at a lower price than a full show of straight vaudeville would require. The policy has succeeded with the result that today there is hardly a house in the country running straight vaudeville.

Bearing in mind, however, that one of the big reasons in vaudeville is to fill out the show at a lower cost per minute, it follows closely that houses buying good vaudeville cannot afford good pictures and must necessarily regard the film as subordinate to the vaudeville. Such being the case, it naturally follows that the combination show must still be a variety show in which little or no relation exists between the vaudeville items and the feature picture. There can be no cohesion to the bill as a whole.

Meantime the big motion picture theaters have been growing bigger. Having succeeded in attracting evergrowing audiences and in appealing to what would otherwise have been the old-time vaudeville patronage, the tendency has been away from the straight motion picture show and towards the show with "presentations,"

big orchestras, and the like. Here the one aim has of course been to get the largest possible attendance for the big pictures, but the more important aim has been at the same time to bolster up weak features and so fill up the deepest valleys in a fluctuating series of weeks. Picture houses like the Eastman Theater, which selects the best from a purchase four times its requirements, are the exception rather than the rule. Most big houses, particularly those in New York, (which naturally are largely imitated) are tied to a particular brand of product and must play the weak ones as well as the successes. The management of such theaters being unable to do anything to improve the features themselves turn their attention to the rest of the program and stick in anything that will help attract business.

All deluxe theaters in New York live on the remains of Rothafel's policies. His has been the one original mind in deluxe presentation. When he, graduating from a 5,000 seat theater, opens one seating 6,200, his competitors are tempted to follow his ways. The Capitol, having a better line of pictures than the Roxy can get, contents itself with increasing the orchestra to 85 men. The Paramount slaps on massive acts of tinsel and gaudiness. The Roxy itself is not immune from the disease. There they slash away at the 11,960 feet of "What Price Glory" until it can be run in 90 minutes. Why? Well, anyhow they made room for a prologue lasting for half an hour. But the prize spectacle could be seen at the Paramount this past summer when the Whiteman Band so completely dominated the electric signs and newspaper ads that the feature was quite lost in the shuffle—and this in the house owned by the producers! The situation has grown top-heavy. Rothafel with his immense reputation can doubtless get away with it, for the public knows that he gives a show, and the public will come whatever the weakness of his feature picture. Already others like Hugo Riesenfeld are talking about the "dignity of the simplicity of presentation" and making capital of the opposite.

In all this floundering what is the ideal for which to work? New York with its unique floating population need not worry about ideals. Yet, that is the problem facing all exhibitors who, like ourselves, must appeal to virtually the same audiences week after week. First and foremost let us recognize that the movie-goers aggregate the largest audiences that have ever patronized any of the arts. So large is the following that there is no effective substitute for the movies. When Chicago houses were recently shut down, the "legits"

did not gain appreciably. It follows that whoever places the film first in importance will appeal to the greatest numbers and do the biggest business. To such an exhibitor there is nothing to be gained by setting up a variety show along vaudeville lines. That policy may be best for combination houses buying only the cheapest pictures, but the public interested in this form of entertainment has never been more than a small fraction of the vast array of movie goers. The exhibitor who has the best pictures will do better to play them with no presentation at all than to surround them with incongruities.

First in importance comes the feature, for it, after all, will chiefly determine the success of the show.

Second in importance comes the weekly film news. The addition of two news reel services this season, I regard as the most significant accomplishment of the year. We purchase all six national news reels. True, the addition of these services has increased our expense, but the extra cost is well worth while. For good measure we add a seventh, which is the Rochester Film News. This Rochester Film News consists of motion pictures taken by the staff photographer of one of our local newspapers. Those events suggested by our Publicity Director as being of general interest to the citizens of Rochester are photographed and the shots developed by the Eastman Kodak Company. The pictures are then sent to the Eastman Theater for use if we consider them satisfactory for showing. The expense of this service is borne by the newspaper and the Eastman Theater, the newspaper furnishing the photographer and the camera, and the theater paying for the development of the film. I cordially recommend this to exhibitors in other cities as bringing the biggest return on the money invested.

Third in importance come the short subjects. As I stated a year ago, we cannot often make use of two-reel comedies, nor are there often so many really good ones, but the single and half-reel subjects are of great importance. Among these the new Metro Oddities added to the Fox Varieties, the cartoons, and novelties of other companies are proving most welcome.

Having now our film, what comes next in importance? Here I unreservedly place projection. Careful and adequate projection must be assured before it is worth bothering with orchestral accompaniment or stage effects. And by projection I mean to include all the lighting embellishments, patterns, etc., besides a cleanly

projected picture. In my opinion there is almost a virgin field in the art of projection embellishment. At the Eastman Theater we have made, I am proud to claim, considerable progress in this art, and when our projection engineer, Mr. Townsend, gets some free time after completion of the papers which he is presenting at this convention, we shall undertake a general paper along this line.

Orchestral accompaniment comes next. There is little to add to what I have already stated under this head beyond the fact that this season I am experimenting with continuous orchestral accompaniment by splitting the orchestra into two units when the overture and acts are over and the feature begins. Half of our orchestra, totaling 68 men, is sufficient for the accompaniment of most features, and half can rest while the other half plays.

I come now to the subject of acts, which play an important part in the makeup of a bill. The important points to remember are:

1. The bill as a whole must build up to the feature, never overshadow it.

2. The bill must contain variety in character and tempo.

3. Yet the bill must make a cohesive whole so that Mrs. Smith will tell Mrs. Jones across the back fence the next morning "Be sure to see the Eastman program this week. The picture isn't so much, but I wouldn't have missed the show for the world!"

I am completely convinced that this type of bill is possible only when the acts are originated in the theater by ourselves. I see no way of rounding out the character of a bill by setting an imported act against a feature. Since traveling acts are largely vaudevillian in origin, the inclusion is merely a step in the direction of the very combination show which I wish to avoid.

As no two features are exactly alike, so no two shows are exactly alike. There are therefore no set rules for making up the bill. The chief ingredient in making up a bill is idea, just as the chief ingredients for a stage act are good ideas for the beginning and ending. After four years' grappling with this problem, I have learned one important thing, and that is to separate completely the "what from the how." With this thought in mind, we have developed at the Eastman Theater a unit which for want of a better term I call the "Scenario Department." This is a staff function, responsible for nothing more and nothing less than preparing act scenarios appropriate to each bill as it comes up for consideration. The head of this department, who sees all the pictures which are to come to the Eastman, prepares

the bill and makes a write-up of each act. I look upon this as an entirely new profession. After determining in this way what we are going to do, we can discuss the approved write-ups with the stage director and consider how they are to be presented. He then brings them to regular weekly planning meetings attended by the heads of the Orchestra, Scenic, Costume and Projection Departments, not less than two weeks before the show is to go on. The stage director is the coördinator of all work connected with the preparation of the show. He is also responsible for the rehearsals right up to the dress rehearsal in the theater on the Friday morning preceding the Sunday on which the show opens. The stage director continues his work with the cast in the acts for the remaining 20 performances of the week after the show is set.

The number of items on each bill will depend on the length and character of the picture. "Ben Hur," and "The Big Parade," for example, call for no overture but require a short prelude leading into the stage prologue, which in turn leads directly to the feature without interruption. Farce comedies and gala bills, on the other hand, call for great variety and will contain as many as eight items. I realize that there is no one right way of making the ideal program. There are many ways of building a bill around any feature. Our main purpose is to select the items which we can put over successfully and which in exhibiting suitable variety will lead the audiences gradually and without abrupt breaks through various moods up to the opening of the picture which must come as the climax. A short film, light in character, is necessary as a "chaser" to follow any feature which may end with a sombre note.

DISCUSSION

DR. MEES: I have merely read this paper; I am not responsible for the statements made in it.

MR. MCGUIRE: I am going to ask Dr. Mees to see that the Publicity Committee is provided with at least eight copies of Mr. Clarke's paper so that they can be forwarded to the trade papers for the earliest possible publication. Mr. Clarke's paper is of great practical value and clearly shows what this Society is doing to deserve the support of the motion picture industry.

MR. RICHARDSON: In my opinion, Mr. McGuire is absolutely right; it is a very valuable paper, but I don't believe in the present

situation it would be possible for the trade papers to publish the paper in its entirety.

DR. MEES: As to whether such a paper is desirable for presentation at the meeting of the Society of Motion Picture Engineers, I believe Mr. Clarke is entirely justified in bringing his ideas before the Society. I am very astonished to hear Mr. Richardson say that the trade papers have not room for the paper in its entirety. It seems to me that the paper would be of the greatest interest to the exhibitors who read the trade papers.

MR. RICHARDSON: As to publication in the trade papers, I have no apology to offer for what I said. The trade papers cannot give space which they have not got. Every week we have material to fill two hundred papers or more, and we cannot use it all.

DR. MEES: Who subscribes to these papers?

MR. RICHARDSON: A great many people; we have almost 1000 projectionists. The bulk are the exhibitors, and we try to bend every energy to serve the exhibitor.

DR. MEES: I am enthusiastic about the presentation of this paper. A theater owner or manager who is running his theater is doing an engineering job and is a legitimate member of the Society, and the subject of the paper comes properly within the province of the Society.

I was astonished to hear, however, that the trade papers have not sufficient room for it. Although Mr. Richardson has explained this, it still amazes me when I consider the pages—not in his department—devoted to such pictures as those of bathing girls, which I pass over hurriedly in order to find his remarks on projection.

SOME TECHNICAL ASPECTS OF THE MOVIE-TONE

EARL I. SPONABLE*

- I Introduction
- II Description of Movietone System
 - A Recording:
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 - Microphones
 - Amplifiers
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 - B Processing:
 - Development of negative
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 - C Reproducing:
 - Projector attachment
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 - Theater Acoustics
 - Projectionists
- III Uses of Movietone

THE general subject of the making and showing of motion pictures in synchronism with sound has been covered recently by papers presented before this society at the last two successive meetings and also in recent articles appearing in many of the current trade and scientific publications. The conception of the idea of sound motion pictures is not new, but practical commercialization of the art has been dependent upon the perfection of sound transmission apparatus and the solution of problems relating to various vital parts of the whole system.

In this paper it is intended to cover briefly the making and presenting of the Fox-Case system of sound motion pictures trade named "Movietone" and to emphasize various parts of the process peculiar to this system that have not previously been described.

The theatrical success of any system of sound motion pictures is

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destined to bear a definite relation to its practicability and to the faithful reproduction of sound without embellishments or special qualities added to the original. The theater is especially critical of this last named condition inasmuch as the audience must hear the reproduced sound over a period of time, and any distortion will cause a very tiring effect upon the listeners. The novelty of "talking pictures" is past. Now, unless the illusion is so very real that the hearers are unaware of the process involved, the system will surely be doomed to failure.

The making of Movietone pictures is carried out in three general steps; namely, recording of the sound and picture, processing of the film, and reproducing.

Recording

Whenever sound is recorded in an enclosed area, usually two conditions have to be satisfied. These are the exclusion of foreign noise necessitating sound proofing of the studio and reduction of room resonance or echo.

The present recording rooms at the Fox-Case Studios were designed from experience gained in the construction of three previous experimental studios, the study of some of the modern broadcasting rooms, and through experiments relating to acoustical materials. It was decided that at least two separate recording studios were necessary. These rooms were constructed sound proof from street noises and from each other. It is possible to have sets being prepared on one stage while recordings are being made on the other.

The sound proofing is accomplished either by using very thick masonry walls or by using a double wall with an air space and a sound absorbing material within. The inner walls of our studios are made with 4-inch solid gypsum block, 1 inch of hair felt, 3 inches of air space, and another 4-inch solid gypsum block wall. These walls are started about 6 inches down in the concrete foundation. The outer walls are made of brick and masonry and are about 24 inches in thickness. A double ceiling is supported from the roof trusses. It is made of concrete plaster and separated by a 3-inch air space and 1-inch hair felt. The floors of the studios are covered with soft carpet. The inner walls and ceilings are covered with Celotex and further damped by hanging heavy Monk cloth drapes perpendicular to the walls and ceiling. These drapes are arranged for raising and lowering, so that the degree of resonance may be varied to meet different conditions of recording.

This special arrangement of damping shown in Fig. 1 was found to be equivalent to covering the walls with 3 or 4 inches of hair felt



FIG. 1. Cloth drapes for controlling resonance in recording room.

and possessed the advantage over felt that the absorption of the sound was quite independent of frequency.

A small and a large stage have been equipped in the manner

described above. The small stage is 22 feet wide by 56 feet long by 21 feet high and is highly damped. This condition is used mainly when recording speech. In the case of musical numbers, a certain amount of resonance is preferable. Such conditions have been satisfied in the larger stage, which is 50 feet wide by 80 feet long by 21 feet high. The size of this stage permits the erection of sets for practically all types of present picture requirements. It is also used in recording the musical scores in synchronism with regular pictures. In this work the picture is projected on a screen from a sound proof booth, and the conductor of a selected orchestra follows the pictures, synchronizing such special effects as the score requires, often incorporating many things that promote the proper presentation of the picture and which would be difficult even in the larger theater orchestras and practically impossible for the smaller theaters. The sound from the orchestra is recorded on a film running in synchronism with the projection machine. The sound negative so obtained can then be developed and combined with the regular picture negative to make positive prints having the Movietone scoring on the same film adjacent to the picture.

Those of you who ever visited a broadcasting studio in summer will undoubtedly remember the Turkish bath effect which is secured in insulating for sound and the resultant retention of heat therein. In designing the Fox Case Studios, considerable thought was given to the problem of ventilation. The problem was more complicated than the usual ventilation problem due to the necessity of excluding blower and machinery noises. The air in the present studios is conditioned and is completely changed every eight minutes. The temperature and humidity of the rooms are controlled and held proper for maximum comfort. This installation has proved well worth while in obtaining a higher efficiency from both artists and working personnel. This is especially noticeable in the picture scoring work, where large orchestras are playing over a period of several hours a day.

The picture lighting used in the sound studios is similar to that employed in regular motion picture work. Both hard and soft lights are used. In some cases it was found necessary to quiet down the operating mechanisms and also to change the reflectors in the Cooper-Hewitt lamps to prevent sound reflections. It is probable that later incandescent or improved lighting equipment and panchromatic film will help solve noise problems. In any case, there is a field open for the manufacturer to make better lighting equipment for use in sound picture work.

All of this work of adjusting acoustics in studios would not be necessary if the sound collectors used in recording could be made to act like our ears. Unfortunately, this has not been done and we find the microphone collecting sound in a manner quite similar to what one hears with one ear alone. This condition, together with the fact that in reproduction we usually require little if any more resonance in addition to that possessed by the theater itself, makes the technic of microphone placing an art in itself and something that has a most important bearing on the illusion that will be obtained in the reproduced sound.

For our work, we prefer to employ in most cases sound collectors of the electrostatic or condenser type. This apparatus, together with the auxiliary amplifier equipment necessary to increase the electrical energy picked up by the microphone corresponding to sound variations to a level necessary to operate the recording mechanism at the film, is practically Western Electric standard Public Address equipment. This has already been described to you by Mr. P. M. Rainey in his paper on the Vitaphone.¹

In recording, it is necessary, of course, that the microphone be either placed outside of the camera field or masked. The intensity of sound varies inversely as the square of the distance, thus the problem of suitable position of the microphone is of utmost importance, especially when recording weak sounds. In recording large orchestras and complex musical organizations, the balance of sound must be carefully adjusted through the use of a Monitor system. This system of monitoring is a replica of the standard reproducing system and thus enables one to judge at all times how the reproduced record should sound. In some recording work, we use a number of pick-ups, combining and adjusting these currents through the use of a mixing panel.

Two methods of changing the electrical variations, corresponding to original sound, into variations in light intensity and subsequent exposure of the photographic emulsion are being successfully used in Movietone recording. One of these consists in modulating what is known as a "light valve." This is a development made at the Bell Laboratories and is similar to the device described by H. E. Ives.²

¹ "Some Technical Aspects of Vitaphone," by P. M. Rainey, *Trans. S.M.P.E.*, No. 30, p. 294, (1927).

² "Transmission of Pictures over Telephone Lines," *Bell System Technical Journal*, April, 1925.

its use in connection with sound recording will be described in detail in another paper. The other method involves what is termed the "flashing lamp" principle and consists in modulating an electrical discharge taking place between electrodes in an actinic gas. This gas discharge device is a development made at the Case Research Laboratory and is termed "Aeo" light.

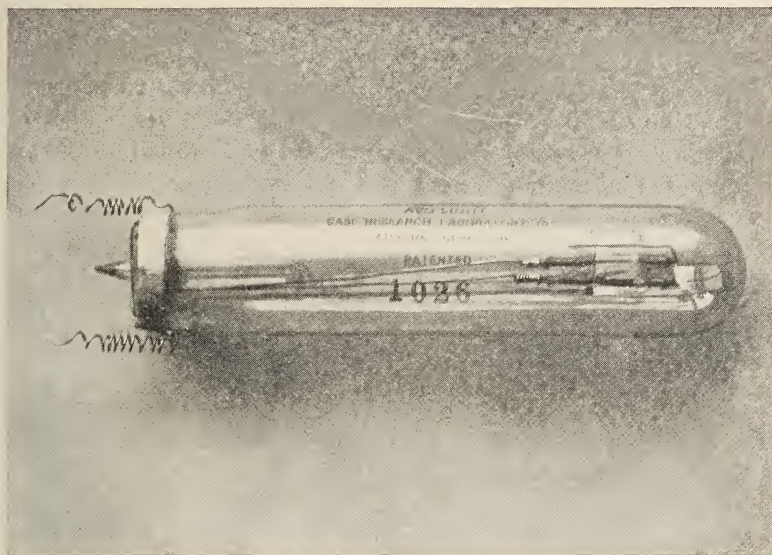


FIG. 2. The Aeo light.

It is fairly simple to make a glow lamp, but to make a light that will follow all the intricacies of the different sounds, from the faintest to the loudest, and do this without distortion and, further, give sufficient light to properly expose a photographic film, has proved an interesting problem. Thus far the "Aeo" light has proved most satisfactory for this purpose. This light is shown in Fig. 2. It consists of a glass or quartz bulb about $1\frac{1}{8}$ inches in diameter and 6 inches long. Two electrodes are mounted close to the rounded end of the bulb. One of these electrodes, the anode, is usually made of sheet nickel about $\frac{1}{8}$ inch wide and $\frac{1}{4}$ inch long. This is mounted opposite a U-shaped cathode of platinum coated with a mixture of alkaline earth oxides. During the manufacture of the "light" the oxide coated loop is activated, and a gas consisting mainly of helium is placed in

the bulb at a pressure required to produce a concentrated glow about the cathode under an applied potential of about 350 volts and a current of about 10 milliamperes.

In use for sound recording, the "Aeo" light is maintained luminous by an exciting battery. Sound currents are superimposed on this luminous discharge causing it to modulate and vary in intensity in accordance with the original variations.

To print the sound image on the negative film, the "Aeo" light is inserted in a tube carrying a quartz slit mounted on a mechanical float, which presses very lightly against the film at the feed sprocket in the camera. The development of this slit was a very important step leading to the making of commercial sound records. The early inventors attempted to use a slit made up of metal knife edges. This was impractical due to the fact it could not be made sufficiently accurate for good sound recording and when placed against the film could not be kept free of dirt. The present slit consists of a small piece of quartz about 0.2 inches square and 20 mil thick. One surface of this piece is coated with a silver film and a slit is ruled in this film having dimensions of 0.10 inch \times 0.0006 inch. A cover glass is then cemented upon the silver and this cover glass polished down so that the thickness of the cover over the slit, including the cement, is less than one one-thousandth of an inch thick. The "Aeo" light is mounted directly back of the slit and as close as physically possible. This type of slit has been successfully used for both recording and reproducing. It is now being superseded by an optical slit wherein the image of the slit ruled on the silvered quartz is focused upon the photographic film. The sound is recorded on standard negative film adjacent to the picture. Fig. 3 shows the dimensions and location of this record. The speed of the film during recording is 90 feet per minute.

During the development of this system it was considered desirable to adhere to standard equipment whenever possible, and this is especially true in the choice of camera equipment. The present Movietone camera was developed from the Bell & Howell motion picture camera. The advantages of this camera for picture making have in a large part been retained. Arrangements have been made for the insertion of the sound recording attachment to print the sound on the feed sprocket. In order to obtain uniform velocity of film at this point and quietness of operation, it has been necessary to install precision gears and make all internal parts with the most exacting

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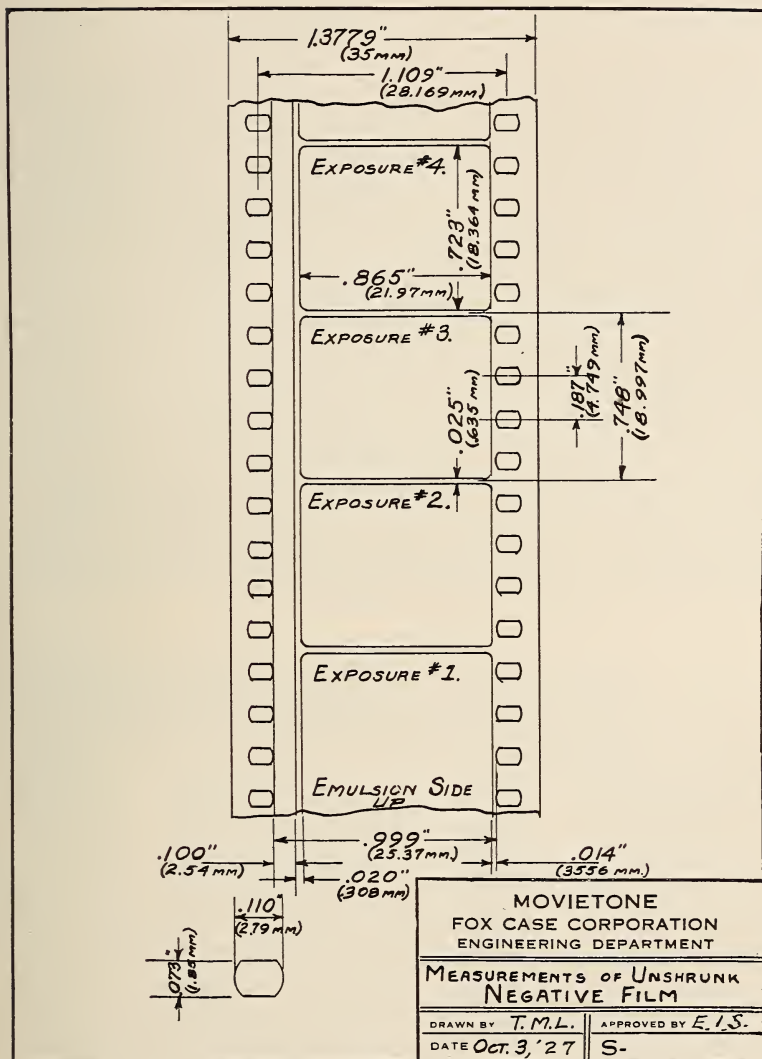


FIG. 3. Dimensions and location of sound record.

mechanical accuracy. A fly wheel has been placed on the sprocket shaft and mechanical filters incorporated to produce uniform motion of the sprocket. In the studio, the cameras are driven by synchronous motors. For portable work, 30 volt direct current motors are used

with rheostat control operated from storage batteries or special spring motors controlled by a governor similar to those of phonograph motors. Fig. 4 shows a general view of a motor-driven studio camera. Fig. 5 shows the method of threading the film and the sound recording tube in position.

A complete field recording outfit consists essentially of a microphone, a special amplifier containing a volume indicator, the "Aeo" light circuit, and a special sound camera. Power for the amplifier is supplied by a 12-volt storage battery and a 400-volt dry cell B Battery. The outfit is transported in a $\frac{3}{4}$ ton automobile truck and manned by a crew consisting of a camera man and a sound man. The apparatus has been amplified to such an extent that the recording work in most cases is being done by men having no special technical training. It is important, of course, that all recording equipment be inspected at regular intervals. To this end a department has been established to service and make measurements on the apparatus regularly.

A number of these outfits are in operation at the present time both in this country and abroad. It is intended within a short time to cover the world for Movietone recording in the manner that the silent news motion picture is covered now. The wide open spaces give acoustically ideal recording conditions. It is probable that in making Movietone feature pictures that the outside recording will be done by a portable outfit and that the lot will be located in some quiet section away from the noise and din of the city.

Processing

The processing of the film is being carried out in our regular commercial laboratory. The negative is developed by rack and tank method for normal time in a fine grain developer. The printing of the positive is at present accomplished by standard Bell & Howell semi-automatic continuous printers of the back shutter type. These are modified by installing masks at the printing aperture to allow for covering the sound track while the picture is being printed and vice versa. The negative and positives are then run through the printer twice. In printing, the sound is shifted with reference to the picture to provide proper synchronism on projection. In the camera, the distance from center of picture with the intermittent about to move, to the sound slit is $7\frac{3}{4}$ inches, the sound slit being on the take-up side. In the projector this distance is increased to $14\frac{1}{2}$ inches.

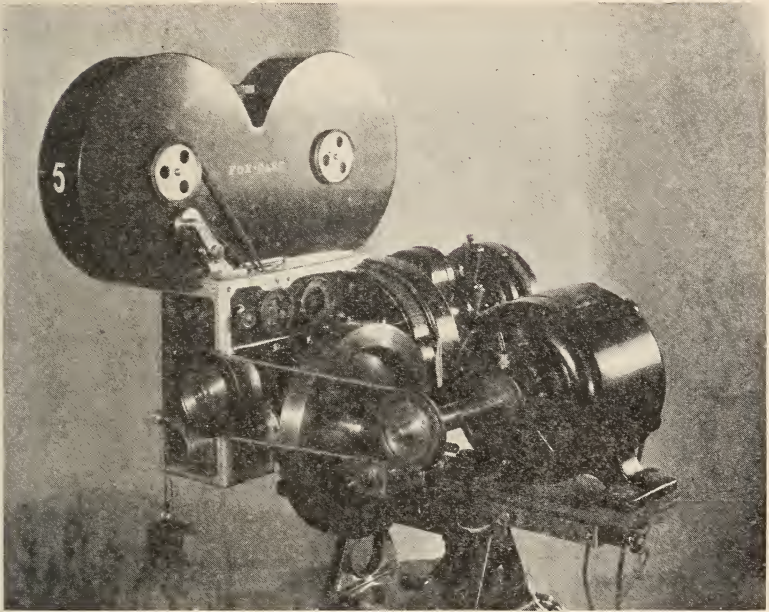


FIG. 4. Motor driven studio camera.

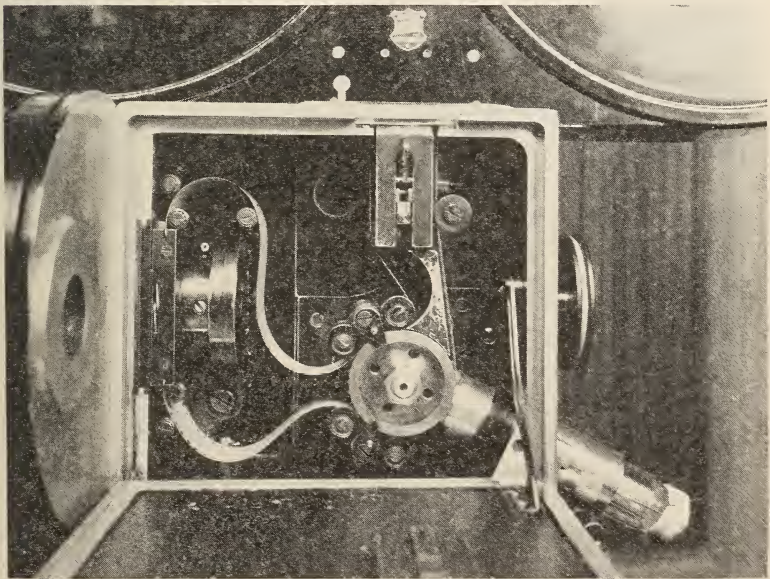


FIG. 5. Camera showing sound recording tube.

It is only recently and with the coöperation of the Eastman Kodak Research Laboratory that we have begun to actually investigate the effect of photographic processing upon the quality of reproduced sound. Some very interesting results have already been obtained. One of the things that bothered in the beginning of the sound recording work was film noise or ground noise. This was at first thought to be inherent in the base or emulsion of the film itself, but it has recently been shown at the Eastman Laboratory that perfectly clean film will reproduce practically without noise. If, however, the film is handled and rewound in the open, dust particles adhere to the film and ground noise appears. This means if the film in recording and processing is kept clean, that practically the only film noise that will be present on the print will be due to the dust and abrasion on the positive. By proper setting of the recording level, this noise will be so low in comparison with the reproduced sound that its presence will be practically unnoticeable in the theater.

In the developing of the positive and negative films, it has been found that contrast and consequently the quality of the reproduced sound follow the conditions necessary for good picture reproduction; namely, that the product of the negative and positive gammas be nearly unity. Fortunately for commercial purposes, these limits are not particularly narrow. It is more important for good quality of reproduction that the transmission of the sound record be correct. All laboratory work is gradually being placed on a mechanically and scientifically controlled basis. This will not only promote the production of better sound records but will improve the picture value as well.

Recording the picture and sound upon the same film make it possible to cut and edit the film in a manner very similar to that used for cutting pictures without sound records. Either the positive or negative can be handled in this manner. In one of the pictures shown here, over one hundred separate shots are included, each of which were retaken several times in the making.

Reproducing

The process of reproducing the sound from the Movietone film consists essentially in moving the sound record through a linear beam of light. The modulations in the form of sound lines on the film vary the light beam in accordance with the recorded sound. These light variations falling upon a photo-electric cell produce corresponding electrical variations which may be amplified and changed back into

sound variations at the loud speaker to give the reproduction of the original sound.

Fig. 6 shows a theater style of Movietone attachment for reproducing the sound. This type has been designed to be applied to the standard Simplex projector and is placed between the head and the lower magazine. It consists of an accurately cut sprocket used to move

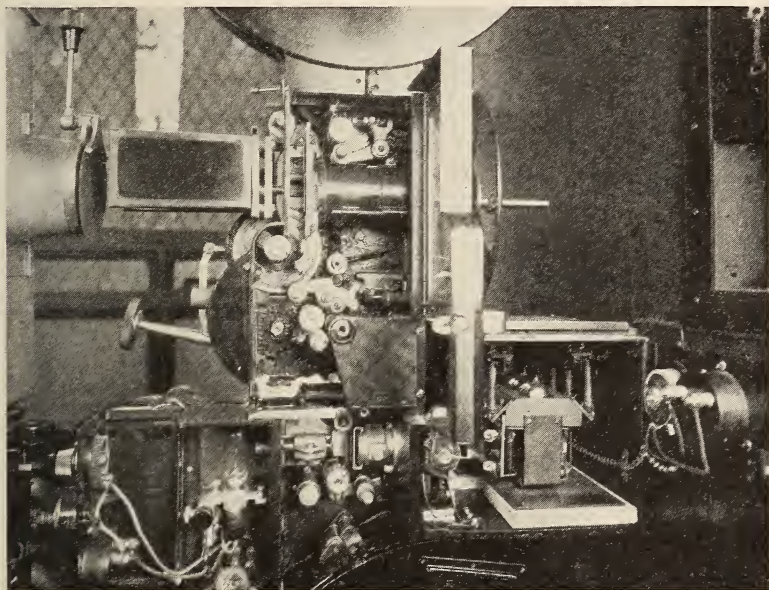


FIG. 6. Projector with sound reproducing attachment.

the film at a uniform velocity between an aperture plate and tension shoe. A 25-watt, 12-volt straight coil filament lamp is focused upon a slit 1.5 mils wide. The image of this slit is then focused upon the sound track on the film at the aperture plate, giving a rectangle of light 0.080 inch \times 0.001 inch. The modulated light passing through the film falls upon a potassium photo-electric cell. This cell is connected to a three tube resistance coupled amplifier which is in turn coupled to a Standard Public Address amplifier system and loud speakers. Uniform motion of the sound sprocket is obtained by placing a rather heavy fly wheel on the shaft supporting the sprocket and driving the shaft through a damped spring mechanical filter system by a tuned motor generator drive.

For the smaller theaters a simplified attachment is used. The tuned motor generator drive is replaced by a synchronous motor or a direct current motor with rheostat control. The motor is belted to the fly wheel of the attachment by an endless cord belt which serves as a mechanical filter of motor pulses and does away with the spring filter mentioned above. The inertia of the fly wheel smooths out any gear inequalities that tend to reflect back from the head mechanism of the projector. In this simpler attachment a barium photo-electric cell picks up the sound variations and is coupled to the main amplifier through a one stage amplifier.

A number of sizes and arrangements of equipment are available to take care of all conditions of projection from the largest theater down to the smallest demonstration room. These are made to operate either on direct current or alternating current as the conditions require.

The Public Address equipment and loud speakers used in reproducing have been fully described by Mr. Rainey in his paper on the Vitaphone. Theaters already equipped for Vitaphone can run Movietone by the addition of the attachment to the projector and a slight re-adjustment of the amplifier system.

In reproducing sound film it is of course necessary that the speed of the film be the same as that used in recording. The standard adopted for all Movietone film is 90 feet per minute. The fact that the sound and picture are on the same film means that synchronism and correct correlation of picture and sound are automatically taken care of. If the film is broken or parts are cut out, the sound and picture are equally affected.

For Movietone reproduction we have developed a special projection screen that is practically transparent to sound and yet possesses a satisfactory surface for the picture projection. This screen is made of bleached cotton yarn woven in a novel manner to allow the passage of sound without muffling and yet reflect a maximum amount of light. With such a material the loud speaker can be placed directly behind the screen consequently producing the illusion that the sound is actually issuing from the point indicated by the action on the screen.

The loud speaker equipment consists of a sufficient number of horns so located that even distribution is obtained in a theater. The horn type loud speaker has a distinct advantage over the cone type in that it is somewhat directional, and with it the acoustical aberration in a theater may be corrected. A horn distributing panel

is used to permit a variable number of horns to be utilized and the volume from each individual horn to be controlled. Theatrical acoustics are of such complex nature that each individual layout must be considered in making an installation. For the smaller theater where there is not room for a horn installation, a disc type of speaker has been developed.

It has been found that the regular projectionists in the theater are capable of maintaining and operating the public address systems. A periodical inspection service and a regular routine of Movietone operation is prescribed which insures against loss of program due to non-functioning or the failure to properly operate the equipment. Development is being made along the lines of reducing all possible error in the handling of the equipment by the installation of such improvements as the optical slit, battery eliminators, centralized control, automatic volume regulation, etc.

Uses

The production and uses of the Movietone are now being developed along a number of different and varied lines. These include pictures of the same type as the silent picture but with sound. These pictures will use the real sounds of life with possibly music inserted where the action calls for it.

Musical numbers where the music is especially composed, as well as the story, form a new kind of picture created by Movietone. Short numbers recording the stars of the stage are made for showing in the smaller cities and towns where the stars themselves never appear in person.

Educational, historical, and religious pictures are being developed. These will speed up and improve our present methods of teaching, incidentally bringing the personalities and teachings of the great within reach of the masses instead of the present few.

Musical scores for the silent pictures can be applied after the silent picture has been finished. These are directed and played by the finest musicians obtainable. Special effects are incorporated that greatly enhance the presentation of the pictures especially in the smaller theaters.

The news reel is being made more interesting and valuable through the addition of sound. In the case of one recent event, the Movietone recording taken and used totaled 1566 feet. On the same

shot the usable silent picture footage was slightly over 100 feet. The sound picture in this instance is still being exhibited.

Other uses of this system are evident and will follow. The home use will develop into an important field. Sound pictures of our children, families, mothers, and fathers especially are desirable.

The preliminary development of the Movietone system was done at the Case Research Laboratory. It was there, during a period when "talking pictures" were considered more or less of a folly, that Mr. Theodore W. Case financed and through inventive genius was instrumental in making the system practical. Later in the face of many complexities, Mr. William Fox undertook its commercialization, and now, through the affiliation and coöperation of the Western Electric Company, this system of sound motion pictures seems destined to a field of public usefulness.

DISCUSSION

MR. RICHARDSON: What effect will oil on the film have on the sound reproduction? Will it not be necessary to handle Movietone films carefully, particularly in the process of rewinding in order that the sound record is not injured; and what will be the effect of longitudinal and vertical scratches on the sound reproduction? How many frames is it possible to cut out in the event of making a splice without affecting the continuity of the sound reproduction? This Society has adopted a minimum of 75 and a maximum of 85 feet per second as the projection speed. Why is it not practical to keep within those limits in making Movietone films? You have developed an effective screen through which the sound will freely pass. Many theaters have an expensive screen through which it would be difficult to make sound pass, and many screens are close to the wall. What procedure do you recommend in such cases?

MR. SPONABLE: With reference to oil, we find that it makes practically no difference in the reproduction of the sound. We have had some film almost dripping with oil, and still this gave fairly good reproduction. Scratches caused in the ordinary handling of the film do not have any appreciable effect on the sound reproduction. A fairly deep scratch caused, for instance, by emulsion caking on an aperture plate, which forms a line one or two millimeters wide, will give surface noise, but the ordinary fine scratches produced in the rewinding of film do not greatly increase surface noise. This summer at the Harris Theater in New York we ran Movietone numbers, about

four thousand feet in all, using the same prints continuously over a period of four months.

With regard to cutting out frames, it depends on the subject. In speech, the film travels at 90 feet per minute, and it takes about half a second to speak a word. One word may be distributed over a length of about 9 inches, so that loss of a few frames will merely take out a part of a syllable but will not destroy its understandability. In music, loss of film is not especially noticeable, particularly where the beat or rhythm is not changed.

Originally we recorded at a film speed of 85 feet per minute. After our affiliation with the Western Electric Company, this was changed to 90 feet per minute in order to use the controlled motors already worked out and used in the Vitaphone system. There are a large number of both Vitaphone and Movietone installations scheduled and in operation, and sufficient apparatus is involved to make it impractical to change the present practice of sound reproducing. In connection with the Society's standard, I have been unable to find any New York theater which is running film at 85 feet a minute; the present normal speed is 105 feet, and on Sundays often 120 feet per minute is used in order to get in an extra show.

The prime requisite in sound picture reproduction is to obtain a good illusion. Loud speakers might be placed at the side of the screen or even in the orchestra pit for musical accompaniments to a picture, but for any talking picture where the sound appears to originate from the action on the screen, the loud speakers must be placed directly back of the screen and preferably in the upper center position. In case the screen is close to the back wall of the theater, we can use a disc type of loud speaker back of the screen.

MR. BAUER: Is the sound recorded at the aperture or at the sprocket where the lamp is, and if so, if the film were to break at the picture aperture, what effect would it have on the sound record so far removed from the aperture?

MR. SPONABLE: The sound is recorded in the camera at the feed sprocket $7\frac{3}{4}$ inches beyond the picture aperture on the take-up side. During printing it is shifted with reference to the picture, and in the projection the distance from the center of the picture to the corresponding sound record is $14\frac{1}{2}$ inches. If the film is broken and spliced, the same space relation between picture and sound is always maintained and there is no loss of synchronism.

MR. COFFMAN: How are the proportions of the picture main-

tained when the synchronized musical score is printed beside pictures photographed with a standard camera aperture?

MR. SPONABLE: In scoring a picture, we run the film through a special printer removing a little from each edge of the picture by displacing the picture negative with reference to the print and thus reserving space for the sound record.

DR. TROLAND: In connection with the application of color to this process; we have had some experience with the Phonofilm, and there was some difficulty in that in the first experiments the sound reproduction had to be done in red or green and the resolution of the sound recording was not as good as desired, but with the single coated process, it is possible to record in black and white and put the colors on independently.

MR. SPONABLE: I remember the experiments in connection with Phonofilm. At that time the thalofide cell was used in reproducing the sound. This was only sensitive to the red portion of the spectrum. With the photo-electric cells now being used, we should obtain very much better results.

THE RENDERING OF TONE VALUES IN THE PHOTOGRAPHIC RECORDING OF SOUND

ARTHUR C. HARDY*

THE desire to make a simultaneous record of sounds and actions is not new. As long ago as February 1888, Muybridge conferred with Edison as to the practicability of using the zoöpraxiscope "in association with the phonograph so as to combine and reproduce simultaneously, in the presence of an audience, visible action and audible words." The phonograph was then less than eleven years old and had not been adapted to reach the ears of a large audience, so the scheme was temporarily abandoned. Although space does not permit a review of the progress of the art since the early days, it is generally agreed now that the ultimate method of sound recording consists in utilizing a narrow strip of the film itself for the sound record. This scheme avoids nearly all opportunity for lack of synchronism between the sound and action and at the same time provides a simple method for the removal of an entire scene when desired.

The purpose of the present paper is to analyze the distortion arising in the photographic part of the process. It is not difficult to prove that such distortion does often exist. The quality obtained in the best of sound records made on photographic film is noticeably inferior to that of radio broadcasting. With a good local broadcasting station and a high quality radio receiving set,¹ the reproduction is as good as would be desired by most persons, excepting possibly highly trained musicians. The electrical and acoustical apparatus used in broadcasting is essentially the same as that used in the production of sound records on motion picture films. We are forced to conclude, therefore, that some, if not all, of the distortion so often present in talking films is due to lack of consideration of the photographic requirements.

The requirements of correct rendering of tone values in sound recording are not essentially different from the requirements of correct tone rendering in ordinary pictures.² Since a considerable amount of

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¹ This combination is unfortunately rare.

² The expression *tone values* is here used in the photographic rather than in the musical sense.

work has been done on the latter problem already, the terminology and the methods now in use in that connection will be adopted as far as possible. An excellent summary of the previous work and a useful graphical method for the solution of these problems has been presented in two papers by L. A. Jones in the Journal of the Franklin Institute for 1920. The present author has assumed a general knowledge of the contents of these papers.

The Method of Recording the Sound

The many methods of making sound records on motion picture film are too well known to require much elaboration in detail. However, it will be necessary to assume some sort of equipment, and so a brief description of one method of recording may not be out of place here. Since the treatment in this paper is largely theoretical, the results are not limited to records made with any particular arrangement of apparatus, as the film has no way of knowing what sort of electrical or acoustical devices precede or follow it.

We shall assume that a microphone is used in the studio to pick up the program—either the voices of the actors or the selections played by the orchestra providing the incidental music. The voltage generated in this microphone is impressed on the grid of the first tube of an amplifier of ordinary type such as is used in radio reception. We shall assume a perfect microphone and amplifier, since we are not concerned with distortion except when it occurs in the photographic phase of the problem. Then the variations in the plate current of the amplifier will be a faithful copy of the variations in the sound pressure at the microphone. This current may be used in either of two ways, leading to two very distinct types of sound records. These are known as the *variable density* and *variable width* types respectively.

We shall consider first the *variable density* type of record, such as is illustrated at the left in Fig. 1. In this type of record, the density is uniform across the sound track but is made to vary along the length of the track by altering the exposure in accordance with the variations in the plate current of the amplifier. A glow lamp or a string galvanometer operating as a light valve are familiar examples of suitable apparatus for this purpose.

In the *variable width* type of record, the exposing light is of constant intensity, but the illuminated part of the width of the track is caused to vary in accordance with the plate current in the amplifier.

An oscillograph mirror adjusted to illuminate half of the sound track when there are no sounds at the microphone will produce this type of record (see right hand side of Fig. 1).

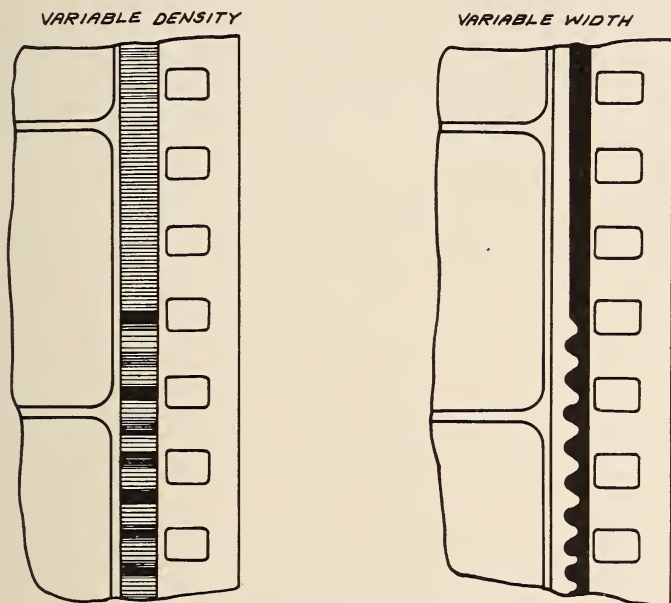


FIG. 1

FIG. 1. Diagram illustrating two types of sound record on motion picture film, known as the *Variable Density* and *Variable Width* types respectively.

The Method of Reproducing the Sound

After a film has been properly exposed in a recording device of either type, it is developed in the usual way into a *sound negative*. This negative may be printed on a continuous printing machine and the result is a positive suitable for reproduction. Either type of record may be reproduced in the same apparatus. A typical arrangement of apparatus consists of a mechanism for driving the film at constant speed, an aperture close to the film,³ and some source to provide an abundance of light at this aperture. Behind the aperture is a light-sensitive cell, the current through which depends on the total amount of light that it receives. In a well constructed photo-

³ It is somewhat better to image this aperture on the film by means of a suitable optical system, but the close-up aperture is simpler to discuss.

electric cell, the current is exactly proportional to the total light flux, and although this current is ordinarily not more than a few micro-amperes, it may be amplified by suitable apparatus and caused to operate a loudspeaker. Here again, we need not concern ourselves with the distortion which might exist in the amplifier if it were not properly constructed, and which usually does exist in loud speakers. Let us remember that the distortion produced by the electrical and acoustical elements is not considered serious when these elements are used alone.

Theoretical Requirements for Correct Tone Reproduction

Before proceeding to the consideration of the requirements for correct tone reproduction, it will be useful to make a few sim-

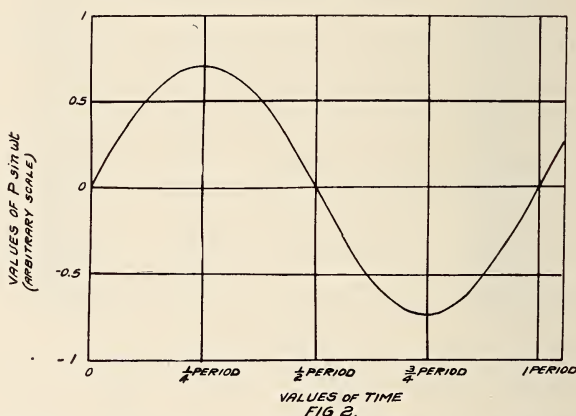


FIG. 2. Graphical representation of a pure sine wave. This type of sound wave has been assumed in this paper for the sake of simplicity. If the reproduction of tone values is correct, the variations in sound pressure produced by the loud speaker are representable by a curve of the same shape.

plifying assumptions concerning the nature of the sound to be recorded. The physical phenomenon which we term "sound" consists in rapid variations in atmospheric pressure. These pressure variations are ordinarily produced by the vibration of mechanical parts or by the vibration of columns of air, as in wind instruments. If the rate of vibration lies between 20 cycles per second and 10,000 cycles per second, the result is a note of audible frequency.⁴ From a mathematical

⁴ The exact limit of audibility is dependent upon the intensity of the source. For all practical purposes, it is sufficient to reproduce all frequencies between 20 and 10,000 cycles per second.

standpoint, the simplest type of variation in sound pressure is a simple sine wave as in Fig. 2. This may be represented by Equation 1:

$$p = P_0 + P \sin \omega t \quad (1)$$

where P_0 represents the average atmospheric pressure upon which is superimposed a sinusoidal variation of amplitude P . Although a simple sine wave of this sort is rarely produced by any musical instrument, we may always analyze any musical note into a fundamental sine variation plus a number of harmonics or overtones.⁵ The quality, or timbre, of a musical instrument depends on the relative amplitudes of these harmonics. However, for the purposes of the present paper we need to consider only a simple sine variation, such as is shown in Fig. 1, since any method which will reproduce the fundamental faithfully will likewise reproduce the harmonics, subject only to limitations to be discussed later. Let us assume, therefore, that our problem is to record a simple sine wave of relatively low frequency.

If a perfect microphone and amplifier are used in recording, the current in the last stage of the amplifier may be represented as in Equation 2.

$$i = I_0 + I \sin \omega t \quad (2)$$

This current consists of a constant term I_0 plus a variable term of maximum amplitude I multiplied by $\sin \omega t$. The condition for correct tone reproduction in the photographic phase of the problem is simply that the current in the photo-electric cell of the reproducer be expressible by an equation of the form of Equation 3.

$$i' = I_0' + KI \sin \omega t \quad (3)$$

The constant term I_0' in equation 3 need not be related in any manner to the constant term I_0 in Equation 2. However, the amplitude of the variable term of Equation 3 must be proportional to the amplitude of the variable term in Equation 2 as indicated by the presence of the proportionality constant K .

There is a useful concept in sound recording which has no counterpart in the ordinary use of photographic materials for picture

⁵ Consider the case of a musical instrument playing the A below middle C. The fundamental frequency of this note is a little more than 200 cycles per second. For simplicity let us assume it to be exactly 200 cycles per second. In general, this note will consist of the fundamental 200-cycle variation, plus an harmonic with a frequency of 400 cycles per second, plus a third harmonic with a frequency three times the fundamental or 600 cycles per second, and so on, the amplitude falling off rather rapidly in the higher harmonics.

making. Referring again to Equation 1, we find the maximum value of p to be $p_{max} = P_0 + P$, the minimum value, $p_{min} = P_0 - P$, and the average value, $p_{ave} = P_0$. We then define the modulation by Equation 4.

$$m = \frac{p_{max} - p_{ave}}{p_{ave}} = \frac{p_{ave} - p_{min}}{p_{ave}} = \frac{P}{P_0} \quad (4)$$

For obvious reasons the value of m can never exceed unity, since any greater modulation would require a pressure less than zero for some parts of the cycle. The amount of modulation of the air pressure by ordinary sounds is small, but the modulation of the plate current in the last stage of the recording amplifier may be made very large. It cannot exceed a value of unity, however, since the minimum current would then be zero, and it would be necessary to operate on the toe of the characteristic curve of the vacuum tube, thus introducing undesirable distortion. We shall later find it convenient to consider the maximum modulation possible in a given element of the apparatus without introducing distortion.

Tone Reproduction in Variable Density Records

Let us continue to assume a source of sound producing a pressure variation at the microphone represented by Equation 1. Let us further assume the use of perfect acoustical and electrical recording equipment so that the current in the last stage of the recording amplifier may be represented by Equation 2. If, now, the variations in the exposure of the film are proportional to the variations in the current I , the exposure of the film may be represented by Equation 5.

$$e = E_0 + E \sin \omega t \quad (5)$$

Here e is the value of exposure corresponding to a sound pressure p , E_0 is the value of exposure when there is no sound before the microphone, and E is the maximum value of the sinusoidal variation of exposure. As before, the maximum value of e is $e_{max} = E_0 + E$, the minimum value, $e_{min} = E_0 - E$, and the average value, $e_{ave} = E_0$.

We may now proceed to find the photo-electric cell current in the reproducer, following very closely the graphical method devised by L. A. Jones. In Fig. 3, the transmission of the negative has been plotted on logarithmic paper as a function of the exposure. The same curve is obtained in this way as when density is plotted against the logarithm of exposure. This curve represents the characteristics of *Eastman positive film* developed to a gamma equal to unity. The value

of the inertia averages a little less than 0.2 candle-meter-seconds, but to facilitate the reading of the curves, the inertia has been assumed to be exactly 0.2 c.m.s. Positive film is chosen for making the negative because of its superior characteristics in respect to resolving power and graininess.

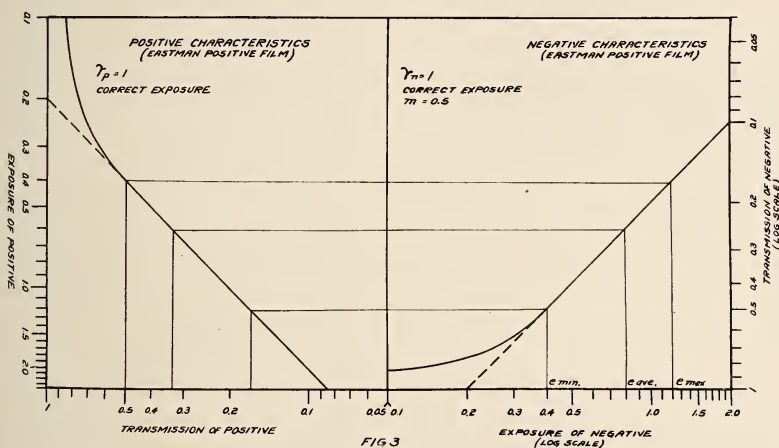


FIG. 3. Tone reproduction diagram representing ideal exposure and development conditions for the *Variable Density* type of record.

The left half of Fig. 3 shows the characteristics of the positive print made from the negative shown at the right. Since the exposure of the positive is proportional to the transmission of the negative, this characteristic curve has been rotated clockwise through 90 degrees. To determine the transmission of the positive corresponding to a given exposure in the negative, we proceed as follows:

Starting from the point on the characteristic scale on the negative corresponding to the exposure in question, we proceed horizontally to the characteristic curve of the positive and then read the resulting transmission of the positive. Thus, an exposure of the negative equal to 1.2 c.m.s. will produce a transmission of the positive equal to 0.5. For reasons to be discussed later, the printing light has been chosen so as to produce an exposure of 2.4 c.m.s. in the positive for a negative transmission of one.

It is obvious that the greatest amplitude of signal is recorded when the modulation of the negative exposure is unity. It is also clear that the use of a large modulation reduces the effect of the ground noise. However, if the modulation of the negative exposure is made

as great as unity, it is necessary to utilize the curved portion of the negative characteristic curve. Thus, if the average exposure is E_0 , the maximum exposure will be $2E_0$, and the minimum exposure will be zero. We see from the negative characteristic curve that a minimum exposure less than 0.4 c.m.s. would place some part of the record on the toe of the curve. From the work of Hurter and Driffeld, and others since their time, we suspect and will later show that this would introduce serious distortion. Let us assume a reasonable value of m for the present, say $m=0.5$. This will provide only half as much signal on the film as a modulation of one (if we could use it), but this deficiency may be compensated by subsequent amplification. To be sure, this will double the amplitude of the ground noise, but when all other conditions have been properly chosen, the ground noise is not a serious problem. With a modulation of 0.5, and the minimum exposure at 0.4 c.m.s., the average exposure must be 0.8 c.m.s. and the maximum exposure 1.2 c.m.s. (as indicated in Fig. 3).

The loudness of the signal depends upon the amount of light reaching the photo-electric cell. Therefore the positive exposure should be kept as short as possible, but for the reasons mentioned above, the toe of the curve must not be used. Thus, the best possible adjustment of the printing light is that which gives an exposure of 0.4 c.m.s. to the positive through the densest portion of the negative. The curves in Fig. 3 have been adjusted to represent this case.

By means of the above method, the reproduction of a sine wave has been determined for a number of cases, a few of which are represented in Fig. 4. These curves are obtained by plotting the transmission of the positive T_p as a function of the time t . Curve C shows the wave form resulting from the exposure and development conditions in Fig. 3. This curve is exactly like that of Fig. 2 and indicates that there has been no distortion in the photographic process. This result is easily predictable from previous work on the theory of the reproduction of tone values. It has been shown that if the product of the gamma of the negative and the gamma of the positive is equal to one, and that if all the tones of both negative and positive are reproduced on the straight portions of the characteristic curves, there will be no distortion. In other words, the transmission of the positive will be directly proportional to the exposure of the negative. Since the current in the photo-electric cell is proportional to the transmission of the positive, this is equivalent to the previous condition that varia-

tions in the current in the photo-electric cell be proportional to the variations in the current in the last stage of the amplifier of the recording unit.

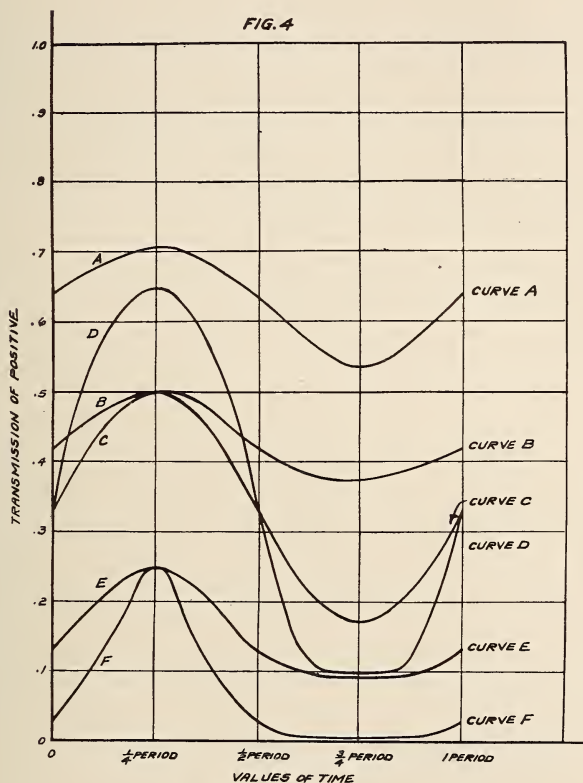


FIG. 4. These curves show the manner in which the pure sine-wave sound of Fig. 2 is reproduced by the *Variable Density* method. Curve C is also a sine wave obtained by proper exposure and development of both negative and positive (shown in Fig. 3). Curve A represents correct exposure but under-development and Curve F correct exposure but over-development. Curves B and E show the effect of under-exposure in the negative, the negative being also over-developed in the latter case. Curve D shows the effect of over-modulation of the negative exposure. The seriousness of the distortion illustrated in all of these curves except C can be appreciated only after the listening test.

A few other conditions of interest are also represented in Fig. 4. In all these curves except curve D, the modulation of the negative exposure has been assumed to be 0.5. Curve A represents the case where both negative and positive are correctly exposed; that is,

all the tones were placed on the straight portion of the characteristic curve, but both negative and positive were developed to a gamma of 0.5. It will be seen that the curve is no longer symmetrical. Different development conditions are shown in curve F, where both negative and positive, although correctly exposed, were developed to a gamma of 2. These curves are equivalent to a fundamental sine wave of the same frequency as curve C plus harmonics introduced by the faulty development. Since the quality or timbre of a musical note depends on the ratios of the amplitudes of the various harmonics and fundamental, this kind of distortion is evidently very serious. A skilled violinist is careful to bow in a manner which produces the overtones in the proper ratios. In fact, from a mathematical standpoint, the only difference between a Stradivarius and a fiddle is in the ratios of the overtones they will produce. We see therefore that it is important in variable density records to develop the negative and positive to a gamma-product equal to unity.

Curve B represents the case where both negative and positive were properly developed, but the negative was under-exposed, being given only one quarter of the amount of exposure indicated in Fig. 3. There is always a temptation in the case of under-exposure to remedy the error by increasing the extent of the development. This case is represented in Fig. 5, where the average negative exposure is only 0.2 c.m.s., and both negative and positive were developed to gammas equal to two. The conditions represented in Fig. 5 lead to a wave form shown in curve E of Fig. 4. It will be seen from curves B and E that the general effect of under-exposure is to flatten one-half of the wave.⁶ Besides introducing harmonics, this decreases the amount of signal on the photo-electric cell, since the signal strength depends roughly on the difference between the maximum and minimum transmission of the positive. Over-development after under-exposure in an effort to increase the signal strength (as in curve E), simply introduces more distortion. The seriousness of this distortion can be appreciated only after a listening test.

As stated previously, all the curves shown in Fig. 4 are plotted for a modulation of 0.5. In practice, this represents an upper limit to the modulation. By proper adjustment of the gain in the amplifier

⁶ This is true of both the negative and the positive. However, under-exposure of the positive would have flattened the other half of the wave. Since we are not interested in phase relations, only under-exposure in the negative has been considered.

preceding the recording unit, the modulation produced by the loudest sound can be kept below this limit. Thus, in musical terms, 50% modulation can be made to correspond to the entire orchestra playing *fortissimo*. As the modulation decreases, the quality of the reproduction improves; that is, errors in exposure or development of the negative or positive are not so serious. If it were not for the back-

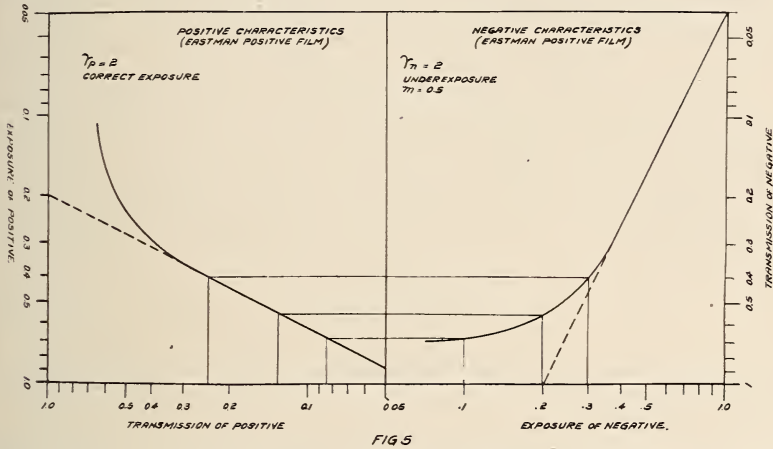


FIG. 5. Tone reproduction diagram for the conditions of exposure and development leading to Curve E of figure 4.

ground of ground noise produced by the graininess of the emulsion it would simplify the photographic technique to use a lower modulation and to build up the signal strength in the amplifier preceding the loud speaker. With the emulsions which are available at present, however, better records are produced by adjusting the maximum modulation to approximately 0.5 and using care in exposure and development.

Tone Reproduction in Variable Width Records

Let us consider the type of record represented on the right in Fig. 1. When the optical system is in proper adjustment, and there is no sound in the microphone, one-half of the path occupied by the sound record will receive no exposure, while the other half will receive an exposure which depends on the intensity of the light, the speed of the film, and the dimension of the aperture in the direction of motion of the film. Let us assume sufficient light intensity so that at normal film speed this dimension of the aperture may be made small compared to the wave-length of sound as recorded. Assuming

the sound to consist of a simple low frequency sine wave as before, the boundary between the exposed and unexposed portion of the sound track is also a simple sine wave.

Let w represent the full width of the sound track and x the width of the exposed portion. Let T_1 represent the transmission of the film in the unexposed region and T_2 represent the transmission in the exposed region. The current (i) in the photo-electric cell is then given by Equation 6.

$$i = k[T_1(w-x) + T_2x] \quad (6)$$

The constant k depends on the sensitivity of the photo-electric cell and the illumination of the film in the reproducer. Assuming a variation in sound pressure representable by Equation 1, the value of x with suitable electrical apparatus in proper adjustment will be given by Equation 7 where f is the fractional width of the track that is utilized.

$$x = \frac{w}{2} - \frac{wf}{2} \sin \omega t \quad (7)$$

Substituting the value of x from Equation 7 into Equation 6, we obtain Equation 8.

$$i = \frac{1}{2}wk(T_1 + T_2) + \frac{1}{2}wfk(T_1 - T_2) \sin \omega t \quad (8)$$

This is of the same form as Equation 1 and consists of a constant term plus a sinusoidal variation of the same frequency as the original sound. It will be noticed that the amplitude of the variable term is proportional to the width of the sound track, the intensity of illumination of the film in the reproducer, the sensitivity of the photo-electric cell, and the difference between the transparency of the exposed and unexposed regions ($T_1 - T_2$).⁷ The maximum modulation (m) of the photo-electric cell current is the ratio of the amplitude of the variable term to the constant term as given in Equation 9.

$$m = \frac{\frac{1}{2}wfk(T_1 - T_2)}{\frac{1}{2}wk(T_1 + T_2)} = \frac{T_1 - T_2}{T_1 + T_2} f \quad (9)$$

The maximum modulation approaches unity as T_2 becomes negligible compared to T_1 . It will be seen by referring to Equation 7 that a faulty adjustment of the boundary between the unexposed and ex-

⁷ Thus it is unnecessary for T_2 to be extremely small. It needs only to be small compared to T_1 , and little is gained by making it smaller than 1/10 (density = 1)

posed region⁸ does not change the quality of the reproduction provided x is always positive and less than w . The relative values of the constant and variable terms in Equation 8 are altered, reducing the maximum permissible modulation, but the reproduced sound is still representable by a sine wave.

Thus, we find that the quality of the sound reproduced by the variable width type of record does not depend on the conditions of exposure or development of either the negative or the positive.⁹ A further advantage of this type of record appears on inspection of Fig. 3. With records of the variable density type, it is impossible to reproduce from a negative, since the transmission of the negative is not proportional to the exposure for any value of γ nor for any portion of the characteristic curve. The greater the modulation, the more serious is the departure from strict proportionality. On the other hand, a negative of the variable width type will sound exactly like a positive. This is an advantage when it is desired to make several master negatives from which to print a large number of positives. When using the variable density method, it is necessary to use the original negative to make the first positive. The master negatives must then be printed from this positive and the final positive print made from these. Thus there are four steps in the process, each additional step making the procedure more troublesome because of the necessity of making the final γ product equal to unity and also because of the practical difficulty of avoiding spots in the final positive due to dust and dirt accumulated in the process.

It must not be assumed as a result of this investigation that records of the variable width type are always free from distortion while good records of the other type are impossible. By using suitable photometric and sensitometric control, it is not difficult to produce excellent records of the variable density type.

There are other kinds of distortion common to both types of record which have not been considered at all in this paper. To

⁸ (so that $x \neq \frac{w}{2}$ when there is no signal)

⁹ It should be noticed that the edge of the variable width record is here assumed to be sharp. In case there is any fuzziness of the edge, it must always lie within the width of the sound track; otherwise, the requirements of the variable density type of record must be met also. When the fuzziness is purposely extended so as always to cover more than the aperture, there is a further requirement that the exposure must be a linear function of the width of the film.

simplify the present treatment, it was convenient to assume a pure sine wave of low frequency. Since the film speed in the reproducer is approximately 17 inches per second, the wave length of a 100 cycle per second note (measured on the film) will be 0.170 inches. In this case, there is no difficulty in making the aperture small (in the direction of motion of the film) compared to a wave-length of sound as recorded. Furthermore, there is little loss in quality due to lack of resolving power of the photographic material. However, if the frequency of the sound is raised, these factors become troublesome. The aperture must be made smaller and must be placed closer to the emulsion. Also, care must be taken to use a photographic technique that will utilize all the resolving power of which the present emulsions are capable. With apparatus of suitable design and with care in the choice of the photographic conditions, it is not impossible to record frequencies of ten thousand cycles per second or even higher, using the normal film speed. The distortion that may be caused by such factors as the size of the aperture, insufficient photographic resolving power, etc., is to be made the subject of a later paper.

DISCUSSION

MR. SPONABLE: I am glad that a man like Professor Hardy is carrying on a scientific analysis of photographic sound recording. I should like to see such a paper backed up by actual experimental demonstration to see how far the theoretical results can be confirmed by actual sound recording. I have made some experiments along these lines and find that the gamma of development does not seem to be as important as one would judge from the appearance of Mr. Hardy's curves. For instance, I find that holding a correct transmission of the sound record is more important for good quality in Movietone work than developing to an exact contrast. I do not know that my results are conclusive and suggest that some laboratory such as Eastman's should experimentally investigate this entire field.

DR. MEES: Another point arises out of this. Mr. Hardy's conclusion, which is quite orthodox in connection with sound reproduction, that we need a virtual gamma of unity is correct. We will have trouble with our pictures, however, because in practice you cannot make motion pictures with a virtual gamma of unity. Scatter affects the actual reproduction for screen purposes and makes a gamma considerably above unity desirable; 0.8 is usual in the negative and 1.6 in the positive, which makes a virtual gamma of 1.3. I hope that

Mr. Sponable is right and the distortion due to a somewhat different gamma is not serious in the sound work, because I think it will be in the pictures. Mr. Jones has studied this subject.

MR. JONES: We are planning to make a careful analysis of the effect of wave form on the reproduced sound, and of course what the outcome will be is difficult to predict. I think we are planning to make the type of study that Mr. Sponable suggested—to impress on the film waves of known shapes and frequencies and determine by analysis the effect of modifications in processing technic; that is, the effect of using different negative and positive gammas, etc.

I am not sure as to Mr. Hardy's conclusion regarding the variable width method, but as I interpret it, it is that it is practically free from the influence of photographic procedure; that is, the product of the positive and negative gammas does not need to be unity. In case that is his conclusion, has he considered the effect of the spreading upon development of the image and the effect of what we have called "astro-gamma;" that is, position and shape of the edge gradient curve?

MR. HARDY: In regard to Mr. Sponable's suggestion that we determine experimentally the seriousness of the distortions, we have found this method difficult because of the many variables which enter. As the modulation is decreased, the quality in a variable density record tends automatically to improve. This is so because no matter what the shape of the characteristic curve, if you work over only a small region, that region is substantially straight. You can get all kinds of contradictory results in this sort of test unless extreme care is used. Records must be compared that were made at the same time with exactly the same phase and amplitude in the recorded waves, and this is very difficult to control. I plan rather to analyze these curves after the fashion of the electrical engineer and to determine from work which has been done or needs to be done on acoustics how serious the distortion is. We can then determine from the curves the relative amplitudes of fundamental 2nd, 3rd, and higher harmonics and decide what is necessary to make the difference between good and poor quality.

With regard to Dr. Mees' point about a gamma of 1.3 not being satisfactory for the sound records, I think it remains to be seen whether the sound reproduction will be more important than the picture. From some tests made at one time we were able to detect a 15% variation in gamma. As I remarked a few moments ago, it

depends a great deal on the modulation. To eliminate the background of ground noise, it is desirable to use a high modulation, but then the distortion caused by faulty photographic technic is more serious.

With regard to Mr. Jones' question on the variable width type of record, the assumption he made is correct. This type of record is free from distortion due to photographic conditions; that is, exposure or development in the negative or positive.

In regard to the shading at the edge, there are two cases, as pointed out in a footnote in the paper. In one case let us consider a variable width record in which the fuzziness is represented by the width of the line. The necessary condition is that this shaded portion shall not pass the boundaries of the sound track. If that condition is adhered to, the reproduction is still perfect in spite of photographic conditions. If it does pass beyond, the shading must be a particular function of the width; that is, the transmission must be proportional to the width dimension of the film. If this is satisfied, the record is still free from distortion.

MR. KELLOGG: I think I can mention an experience that many of you have had that may throw light on Mr. Sponable's question. You do not necessarily have to record sound on a film and then reproduce it to get an idea of the effect of distortion of the kind we have been discussing on the quality of the sound. An over-worked tube in the audio stage of a radio receiving set gives a wave form distortion similar to that described in Professor Hardy's paper. The similarity is closest if the tube is worked with too much bias for the plate voltage. Therefore, if the plate battery of a set gets weak but the bias battery stays good and you try to get normal volume from the set, you will bring in such distortion. Another example is the case of the common telephone receiver in which a bi-polar magnet pulls on an iron diaphragm. This has a similar wave form distortion, which does not become large until the magnetic flux due to the voice currents in the coils approaches in magnitude the magnetic flux due to the permanent magnet. The distortion results from the fact that the pull is proportional to the square instead of the first power of the total magnetic flux. If you notice carefully the quality of a voice when the current through the coils is strong or when the permanent magnet of the receiver is weak and compare this with the quality under normal conditions (when the permanent flux is very large compared with the varying flux), you will probably find that the distorting conditions

give a harshness to voice and music as compared with the normal conditions. The distortion, however, is of a kind that would not ordinarily make you criticize the quality of reproduction unless you have an opportunity for comparing it quickly with better reproduction. I believe that this explains why we so often accept systems in which analysis shows that there must be distortion and consider them satisfactory. When we have a distortionless system and can get a quick comparison, there can be little doubt that we would chose it in preference to one in which any distortion exists.

TACHOMETERS FOR USE IN MOTION PICTURE WORK

NICHOLAS M. TRAPNELL*

SPEED indicators when first used on projectors in motion picture theaters were considered a luxury and were only to be found in a few of the best first-run houses. The advantages to be gained by the use of accurate speed indicators or tachometers soon became apparent, however, and today the projectors in nearly every first-run house are equipped with them. It is only by the use of tachometers that the modern theater is able to maintain an exact schedule; that the projectionist is able to run his projector at a definite, constant, speed which will give the best results on the screen; and that the orchestra leader is able to correctly time his score; but it is not only on projectors that tachometers have made possible improvements in technique which would otherwise have been impossible.

Tachometers are now in general use, or are coming into general use, in other phases of motion picture production and exploitation, such as on cameras, where the importance of a standardized constant taking speed has long been recognized and insisted upon by this body; on film developing and printing machinery, where the development time depends on the speed of the machine and where this time must be varied with changes in the strength of solutions; and, more recently, in the two systems of "talking motion pictures," the Vitaphone and Movietone, where the sound recording device must be perfectly synchronized with the camera. There are probably other phases of the motion picture industry where tachometers are now considered a luxury but where they will soon become a necessity; also, there are probably phases where tachometers are not used at present but where much could be gained by using them.

There are certain general conditions which must be met by the tachometer manufacturer in nearly all applications of tachometers to motion picture work, and they may be briefly described as follows:

1. The tachometer must be light and compact. This is especially important on all portable equipment, such as cameras, where any increase in weight or bulk is undesirable.

2. It must require only a very small amount of power to drive it, because on most motion picture equipment there is very little surplus power available for driving the tachometer. This is true on motor

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driven as well as hand driven equipment, since the size of the motors is usually kept to a minimum.

3. The accuracy must remain constant and must not be affected by wear of the mechanical parts. A tachometer whose accuracy decreases with increased wear of its parts is worse than useless after a short time in service.

4. It must be reliable and require practically no attention because most projectionists and camera men have not had the special training necessary to enable them to make repairs on tachometer equipment if they had the time.

5. The tachometer readings must often be transmitted to a point remote from the machine whose speed is being measured, as on projectors or remotely controlled cameras, and it is often necessary to have more than one indicator connected to the same machine, as on projectors in theaters where one indicator is mounted in the projection-room, one in the orchestra pit, and sometimes a third in the manager's office. The tachometer equipment should be so designed that this can be done easily and cheaply.

We now come to a consideration of the different types or classes of tachometer equipment available and the degree to which they meet the above mentioned conditions which is a measure of their suitability for motion picture work. Tachometers may be divided into four general types or classes according to the principles on which they operate.

1. The mechanical type which usually consists of a centrifugal device having a rotating mass whose position is dependent on the speed at which it is rotated and which is mechanically connected to a pointer moving over a scale calibrated in revolutions per minute or other suitable units.

2. The hydraulic type, consisting of a small rotary pump which circulates liquid, usually an oil or glycerine, through a closed circuit in which is an orifice of definite diameter. The pressure of the liquid in the circuit between the pump discharge and the orifice is directly proportional to the speed at which the pump is driven and the speed is measured by means of a pressure gauge calibrated in revolutions per minute.

3. The magnetic drag type, in which a rotating permanent magnet tends to deflect an armature hung on pivots. The deflection of the armature is resisted by a spiral spring, and the amount of deflection is proportional to the speed at which the magnet is rotated. The armature carries a scale which indicates the speed of rotation.

4. The electric type, which consists of a small direct current generator or magneto driven from the device whose speed is to be measured, generating a voltage directly proportional to its speed and connected by means of wires to a voltmeter calibrated to read in revolutions per minute, feet per minute, or other suitable units.

The mechanical type of tachometer, although it can be built in a very light and compact form, is usually far from being accurate in its reading due to wear of its parts; and it is impossible to transmit its readings to a point remote from the machine whose speed is being measured. In spite of these defects, however, it is used to some extent in motion picture work.

The hydraulic type, on account of its large size and weight and the large amount of power necessary to drive it, is never used in motion picture work.

The magnetic drag type is very little used in this work because it is usually necessary to drive it by means of a flexible shaft which consumes considerable power, is subject to wear, and adds materially to the weight and inconvenience of portable equipment.

The electric type is by far the most suitable tachometer for most motion picture work. It can be made very light and compact, its accuracy is not affected by wear of its mechanical parts, it requires an extremely small amount of power to drive it and when properly designed and constructed requires no attention of any kind after installation. Its readings can be transmitted easily to any distance by extending the connecting wires between the magneto and indicator; and as many indicators as desired can be run from the same magneto.

There are now two classes of electric tachometers available for motion picture work. In the older class the magneto generates a very low potential, about eight-tenths of a volt per 1000 revolutions per minute, has a high internal resistance, about 70 ohms, a low output, and a low resistance in the external circuit which includes the indicator and connecting leads. This class has several disadvantages. It is subject to error due to change in resistance of the external circuit which may be caused by faulty electrical contacts or connections or extreme temperature changes. Because of the likelihood of error due to resistance changes, the brushes which bear on the commutator of the magneto are made of a soft-non-corrosive alloy to prevent corrosion at this contact point, and since this is a poor bearing metal, the brushes soon wear out. The magneto, indicator, and connecting leads must all be adjusted and calibrated together and are not interchangeable. The indicators, because of the low output of the magneto must be very sensitive, which makes them delicate and subject to damage due to vibration, etc. This condition is aggravated when more than one indicator is operated from one magneto.

In the newer class of tachometers, the magneto generates a comparatively high potential, 3 to 6 volts per 1000 revolutions per minute; has a low internal resistance, about 20 ohms, high output, and a high resistance in the external circuit, nearly all of this resistance being in the indicator. This class of tachometer, because of its high potential and high external circuit resistance, is not so much subject to error due to poor electrical contacts or connections. The connecting wires may be made any length or diameter within reason, because

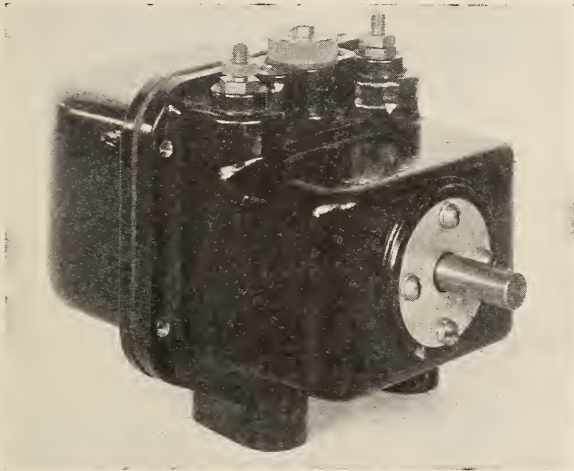


FIG. 1. The magneto.

their resistance is a very small percentage of the total resistance of the circuit. The magnetos and indicators require no special adjustment together with the connecting wires and are all interchangeable. The indicators are more rugged, and as many indicators as desired can be connected to one magneto because of the higher current capacity of the magneto.

I will now describe a good example of the latter class. The magneto, which is part of the tachometer, is a direct current generator having a permanent magnet field and a revolving armature provided with a commutator on which bear the brushes for collecting the current generated in the armature.

The distribution and uniformity of the magnetic flux across the airgap is governed by pole pieces of proper shape, and permanency of the magnetic circuit is obtained by an exceptionally small airgap

and a magnet made of special steel specially treated and aged. The brushes and commutator segments are constructed of special hard non-corrosive alloy having an exceptionally long life. The

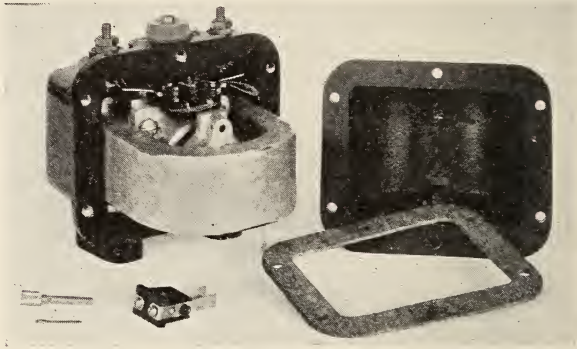


FIG. 2. The magneto (cover removed).

brushes are definitely adjusted for proper position when the magneto is assembled. These and the commutator do not require any attention except cleaning at yearly intervals, and the brushes are so arranged

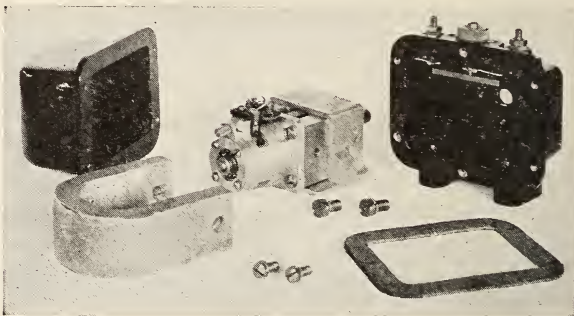


FIG. 3. The magneto (covers and magnet removed).

that they can be easily removed and replaced. The armature is constructed so as to have unusual mechanical strength and is mounted in self-aligning ball bearings which permit extremely free rotation and which require no lubrication or attention of any kind. These are the only moving parts in the magneto.

The magneto is adjusted to generate an E.M.F. of 6 volts per 1000 RPM and to have an internal resistance of exactly 20 ohms. The

voltage generated is directly proportional to the speed; that is, the speed-voltage curve is a perfectly straight line. The terminal voltage may be adjusted to an exact value under different conditions of indicator load by means of a magnetic shunt which can be operated from the outside of the magneto case. After making final adjustments the shunt is sealed. The magneto should be so driven that its normal speed

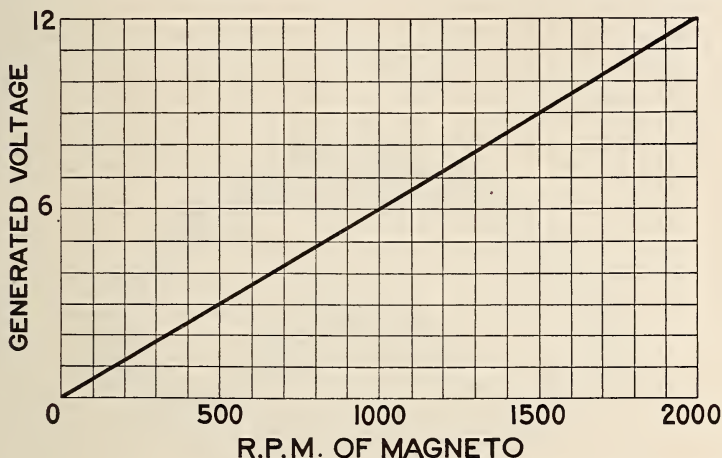


FIG. 4. Curve showing relation between magneto speed and voltage.

is between 1000 and 2000 RPM, giving a normal voltage of between 6 and 12 volts. This can be done by the proper size and arrangement of driving pulleys, gears, etc.

The magneto is compact and light and can be mounted in any position. It can be driven from the machine whose speed is to be measured by means of belt and pulleys, spur gears, or direct connection to some shaft or rotating part running at a suitable speed. The power necessary to drive it is slightly more than 1/746 horse power (one watt), which is less than the power required to drive any other tachometer at present on the market. Its accuracy is guaranteed to be within 1%, although the accuracy will be greater than this under ordinary conditions. That this accuracy remains constant has been proved by severe laboratory tests.

The voltmeter indicators used as part of the tachometer are of various forms and sizes to suit different conditions. The form commonly used with motion picture projectors is a fan shaped instrument having a long and easily read scale and at the same time occupying

but little space. It is designed to be mounted on a panel by means of two studs on the back of the instrument case; these studs also act as binding posts for the connecting wires to the magneto on the projector. The indicator has a double scale. The upper scale shows the film speed in feet per minute, while the lower scale shows the time necessary to project a thousand feet of film when running at the speed indicated on the upper scale.

All indicators are adjusted to have a resistance of 500 ohms per volt; thus, an indicator designed to be used with a magneto whose



FIG. 5. The vultmeter indicator

normal speed is 1500 R.P.M. would be adjusted to 9 volts and would have a total resistance of 4500 ohms. This is the large resistance which eliminates the possibility of errors due to poor connections and long connecting wires.

For instance, suppose the connecting wires were No. 14 B & S gauge copper having a resistance of 3.1 ohms per 1000 feet, and that the indicator is at a distance of 250 feet from the magneto. The total length of the connecting leads would then be 500 feet and their total resistance would be 1.55 ohms. This is 0.3 per cent of the total indicator resistance of 4500 ohms and would cause an error of only 0.3 of 1% in the indicator reading, which would not be noticeable.

The guaranteed accuracy of the indicators is 1%. This, combined with the magneto accuracy of 1% gives a guaranteed overall accuracy of 2% for the tachometer, although the probable error is much less than 2%.

In conclusion, I might say that there are probably many new applications in motion picture work where tachometers could be used to advantage, much as in air-plane photography where several motor driven cameras could be mounted in different locations on the plane and each camera equipped with a magneto. All the magnetos could be connected through a selective switch to one indicator mounted in the cockpit. The speed of all the cameras could then be read and controlled from this one point. Another new and advantageous tachometer application would be on ultra-speed cameras used in scientific work by research laboratories, where the exact time of duration of the various motions or events photographed could be easily calculated if the speed of the film was accurately known.

DISCUSSION

MR. PALMER: We have a tachometer operated by the projection machine, and an enlarged image of the tachometer dial is thrown by a stereopticon lens on to a small screen which is above the main screen in the projecting room. Then, anyone wanting to know how fast the picture is run needs merely to look at the small screen above the large one and read the figure recorded thereon.

MR. STEWART: Could any cameraman be induced to use one of these? I tried the experiment of putting a set screw lock on a tape measure and adjusting the length for 40, 45 and 60 oscillations. A number of our cameramen used them for a month and after that you couldn't find one in the place although the pendulum was acting as a tachometer would.

MR. GREENE: Some time ago I wrote to the Weston people asking for information as to tachometer hook-ups and they recommended indicators in series, and on your diagram I noticed them in parallel. Which do you recommend?

MR. TRAPNELL: We recommend parallel as being more accurate.

MR. GREENE: The reply to my request was as follows: "When connecting a number of instruments to the tachometer it is recommended that they be connected in series rather than in multiple. In this way we could adjust the instrument to a definite sensitivity and a definite potential so that they could at any time be switched from one tachometer to the other, or in case one should become damaged we could readily replace it by another instrument simply by making an adjustment to record those already being used."

MR. TRAPNELL: If you take a meter out of the circuit, you must substitute enough resistance for that taken out.

WHY EXPERT KNOWLEDGE AND HIGH GRADE INTELLIGENCE IS ESSENTIAL IN THE THEATER PROJECTION ROOM

F. H. RICHARDSON*

THE question implied by the title chosen for this paper might be answered with absolute finality and correctness merely by saying: To the end that the work of projection be done efficiently.

This would answer the question, yes, but the word "efficiently," as here used includes many things, or perhaps it were better to say many items, with what is generally termed the "overhead" and the effect upon box office income as the two main objectives.

First, permit me to direct your attention to a fact only now beginning to be recognized; namely, that the motion picture projectionist of the future must be at least to some extent a research man; for example, effect lighting is playing a very large part in the entertainment now provided by the higher class motion picture theaters. It is a foregone conclusion that it must and will play a very important part in the programs of an increasing number of theaters as time goes on, and save for relatively few exceptions this feature must, in the very nature of things, be largely or wholly provided by the theater projection staff.

In this connection permit me to cite the work already done along these lines by Lewis M. Townsend, Supervisor of Projection in the Eastman theater, Rochester, New York. Projectionist Townsend has planned and carried to perfection several elaborate and most excellent lighting effects which have added very largely to the effectiveness of the Eastman theater programs. It is rank foolishness to say or admit that what Mr. Townsend has accomplished cannot be duplicated in other equally beautiful effects by other master projectionists.

It is natural to suppose that theater managers will in due course of time come to look to the projectionist for the creation or planning of various light effects, and we may assume that in this item of his future work lies a fertile field, the exploitation of which will or can be made to add very largely to his prestige and importance; it should also add materially to his remuneration.

That this is probably true I think most of you will heartily agree, but success in creative work of any sort may only be attained by and

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through well directed effort and the application of expert knowledge and high grade intelligence. It follows therefore that expert knowledge and high grade intelligence are essential in projection work, at least insofar as concerns effective work along the lines indicated.

Another possible field for exploitation by the motion picture projectionist which has been but little developed is what may be termed projection stunts, such as the "Magnascope" exemplifies. That effect was planned, at least in part, by a supervisor of projection and, in the eyes of Adolph Zukor at least, it represents a very important advance in projection. That other equally effective "stunts" only await the application of expert knowledge and high grade intelligence is altogether likely, but that they will be discovered and perfected by inexpert projectionists or by those having anything less than high grade intelligence seems, to say the least, highly improbable.

And now let us examine every day projection practice as it exists. It seems almost unnecessary again to direct the attention of this august body to the now very generally recognized fact that imperfections in the projection of any photoplay will operate to reduce its dramatic and amusement value in the theater in which the imperfections occur, and that the reduction in such values, as applies to the performance in which the imperfections occur, will be in exact proportion to the amount of fault existing.

I believe you will be in unanimous agreement with me that the more thoroughly any projectionist understands both the practical and theoretical operation of any mechanisms he may be called upon to use, or any power or light sources and the electrical and mechanical equipment by means of which they are made available for use, or any optical systems or other things which he may be called upon to use in the course of his work, the more effective he will be able to handle them, both from the viewpoint of economy of operation and effectiveness of the finished result.

That last seems to me to be in the nature of a statement of fundamental fact concerning which there can be no serious argument, and if you agree, then we are necessarily in accord upon the proposition that thorough or "expert" knowledge of the various things the motion picture projectionist must handle or use in his work is essential to the highest possible effectiveness and efficiency in motion picture projection.

Let us now examine, somewhat in detail, the effect of lack of knowledge in the theater projection room, with notation, however,

that no amount of knowledge, expert or otherwise, will be of avail unless the man who possesses it is also equipped with sufficient energy, ambition, and pride in his work to cause him to apply that knowledge.

Broadly it may, I think, be conceded by all that the term "efficiency" as applied to motion picture projection will include the manner in which all those various things are done which are necessary to place the image upon the theater screen and to cause the audience to see it at 100% of its dramatic and amusement value, remembering that "the manner in which all those various things are done" will include their being done with the least possible waste of electrical power, the least possible wear and tear upon equipment, and with the least possible outlay for equipment consistent with perfection in the result to be attained.

Considering the item "equipment cost" first, may we not all be in substantial agreement upon the proposition that only the projectionist equipped with expert knowledge and intelligence of at least fairly high grade will be able to select from the fairly long list of offerings that equipment which will (a) provide the best possible service in the matter of a perfect screen image; (b) operate at a minimum in the matter of upkeep and general deterioration and (c) be the most economical of any equipment of equal grade in items (a) and (b)?

I believe you will all be in substantial agreement concerning the foregoing paragraph, since the thing is pretty well self-evident. Therefore, we will without argument pass on to consideration of the need for expert knowledge concerning the various equipment items or some of them at least.

Since motion picture projectors have so very intimately to do with the excellence of the screen image, and since their vital parts work at very high speed and under heavy strain, certainly the vital necessity for expert knowledge of their mechanical construction and of the manner of making the necessary adjustments to the end that the mechanism functions properly will not be questioned.

Two professional projectors, fully equipped, now cost in excess of \$1,500.00, and unless the projectionist thoroughly understands the lubrication requirements of such machinery and applies his knowledge with great care, much damage may be done in either one of two directions or in both of them. If an unsuitable lubricant be used sparingly, the projector mechanism will almost certainly wear very rapidly, and thus an entirely unnecessarily heavy bill for repairs and

replacement parts be incurred. On the other hand, if an improper oil be selected and the projectionist attempts to substitute quantity for quality, great damage may be done to the films themselves.

Surely no argument is necessary to convince you of the literally enormous damage done both to the film itself, viewed merely as property, and to the image projected upon the theater screen by oil smeared upon the film. In this connection it is well to remember that the inexpert or careless (carelessness is one form of inexpertness) projectionist, machine operator or attendant is very likely to place his reliance upon copious lubrication rather than upon the quality of the lubricant. Also do not forget that, aside from over-lubrication, a too-thin oil will have but slight cohesion, hence will be more readily thrown off the rotating projector parts than would a heavier oil. True, projector manufacturers provide an oil especially suited to the requirements of their mechanism, but also it is true that a great many theater managers insist upon purchasing cheap oil from local dealers, which the projectionist will use without protest if he has only slight knowledge of projector lubrication requirements.

Viewing the two items, damage to film by oil and damage to projectors through improper lubrication, it is readily seen that the inexpert man may cost the theater a very substantial sum in the course of a year. Just what damage is done to the box office receipts by reason of injury to the screen image through oil smeared film it is impossible to say, but in my opinion it is not at all impossible that an ordinary theater seating, say 500 might in the two items (box office loss and machinery deterioration), lose fully \$5,000 a year. There may be those who will scoff at such an estimate, but I should advise them to give the matter some thought, because in my opinion the losses not infrequently run even higher.

Another item in which there is great need for expert knowledge and high grade intelligence, is that of screen surface characteristics, which certainly should be a subject well understood by the projectionist. It is now a recognized fact that different shapes and sizes of theater auditorium seating space demand different sizes of picture and different screen surface characteristics.

Certainly the exhibitor and theater manager have every right to expect the projectionist to have at least a fairly accurate knowledge of what picture dimensions will best serve the seating space of the individual theater and what screen surface will serve the individual theater most efficiently. Also it is very essential to efficient work that the

projectionist have accurate knowledge of the effect of various types of theater decorations and auditorium lighting upon the screen image.

The projectionist is the one who is presumed to attend to the placing of the screen image before the audience, and since all these things have directly and intimately to do with the excellence of what the audiences will see, it would be difficult to follow a line of reasoning which disputed his jurisdiction over them or the vital necessity for a thorough understanding on his part of the principles involved.

It is true that the large theater may command the advice of technical experts concerning picture size and screen surface demands, but for every one of those there will be ten of the smaller sort which cannot secure such expert advice and must therefore depend upon the salesman's counsel, which in the very nature of things is controlled at least to some extent by self interest, or else be guided by the knowledge contained in the theater staff itself, and surely the projectionist is the logical one to whom to look for it.

Will anyone argue that expert knowledge of those various things affected by picture size and by screen surface characteristics is not absolutely essential to the giving of competent advice as to the kind and size of the theater screen? Will any man argue that ability to give really competent, expert advice upon such subjects should not form a part and parcel of the motion picture projectionist's equipment, or that the possession of such knowledge would not add very largely to the value of the projectionist to the exhibitor and to his prestige and importance in the theater? I think not!

Recently one of the largest, most expensive motion picture theaters in all the world opened its doors to the public, equipped with a screen so entirely unsuited to the needs of the auditorium and so enormously inefficient therein that it was removed as quickly as was possible after the opening night.

Such a foolish error would not have been committed had the head of the projection staff of that great theater been consulted, and had he been able to apply intelligently the data provided in both the proceedings of this Society and the Bluebook of Projection. By the use of these agencies the chief of projection might have selected exactly the screen surface which would be best and most efficient in that theater, provided, as I have already intimated, he possessed the knowledge necessary to apply the aforesaid data properly.

Manifestly, it is the duty and the function of the theater projectionist to place upon the theater screen the best picture that can

possibly be projected with the films supplied, but in this connection a costly error has been committed by many projectionists by reason of the fact that they sidestep the most important part of their function by saying: "With what is supplied me," instead of "With the films supplied me." By this I mean that they lay the fault of poor projection results upon poor equipment et cetera whereas they are really themselves to blame for the reason that they are not competent to give authoritative advice to the exhibitor, and he knows they are not, hence is obliged to and does take the advice of salesmen and others who have axes of their own to grind. Had they themselves been equipped with expert knowledge and able to demonstrate that fact to the exhibitor, it is altogether possible the results might be very different.

If we are to continue to assume that all the theater projectionist needs to know is how to operate the various items of projection equipment with which he is provided and to make the necessary adjustments thereof, then we will continue to place the selection of the equipment upon which excellence of results must in considerable measure depend in the hands of more or less incompetent men or in the hands of men whose chief interest is to sell their own brand of equipment or the equipment upon which they will realize the greatest possible profit.

The business of the theater manager is to manage the theater. It is not, I repeat, to be reasonably expected that in addition to the wide range of knowledge necessary to successful theater management the theater manager will have expert knowledge of all the relative merits and demerits of the various motion picture projectors, motor generator sets, light sources, screen surfaces, et cetera, plus expert knowledge of theater lighting with relation to its effects upon projection, glare spots, and many other things.

The proper function of the theater manager with relation to projection is, it seems to me, to select a really competent motion picture projectionist, to see to it that he receives films in good mechanical condition, and to demand that he select proper equipment including screen surface if it be a new theater or put things in the best possible condition if it be old equipment and deliver the goods upon the screen well and efficiently.

The theater manager need only have sufficient knowledge of projection matters with the aid of competent textbooks and trade paper technical departments to check up the doings of the projectionist with reasonable accuracy. It is his business and function to secure

high grade intelligence and expert knowledge in the projection room in his theater and then, as far as possible, to be guided entirely by the projectionist in projection matters, which means in all things pertaining to and affecting the screen image as viewed by theater audiences.

It is hardly to be expected that the projectionist will have wide knowledge of theater lighting except insofar as it affects projection. He should, however, have sufficient knowledge of the subject to enable him to offer the architect sound advice and information concerning the effect of light, other than picture light, upon the screen image and what light intensity is accounted permissible in the vicinity of the screen surface. In fact, the projectionist should be required by his employer to have at least a fairly complete knowledge of such matters.

He should be able to inform the architect, for example, as to just what constitutes a glare spot and what the effect of such a spot is upon the screen image by reason of its action upon the eyes of the audience; also, concerning the element of eye strain set up by them. *The architect should be required to give very serious consideration to information of this character when supplied him by the projectionist.* It is manifestly unfair to demand high class screen results from a projectionist and at the same time exclude him from having an authoritative voice in matters directly affecting the screen image he will project.

Gentlemen, I might continue at great length citing reasons why expert knowledge and high grade intelligence are essential to high class, efficient work in the theater projection room, but already this paper has grown too long and sufficient has been said to fully answer the title question.

I doubt if any man present or any who may read this will dare question, much less dispute, the value of expert knowledge in all the things I have named as being available in the theater projection room.

I doubt if any will question the proposition that such expert knowledge ought to be available there.

I believe you will all agree that if such expert knowledge were available in all theater projection rooms, very many costly equipment selection errors would be avoided as well as a very great and continuous waste in both electric power and the altogether too rapid deterioration of costly projection equipment and films; also, that theater income, which is the only income available to the motion picture industry as a whole, would be largely benefited by reason of better results upon theater screens.

DISCUSSION

MR. STEWART: I presume Mr. Richardson is willing to advise how men should be tested before they are employed as projectionists. I know of a case where seven prints were sent out to be projected; six were used in the ordinary way, and after the third or fourth showing, one print came back to the producer. Eventually the theater owner had to pay for this because his projectionist had spoiled it. He was absolutely responsible for the destruction of the reels of film, which is another expense which might be added to those of which Mr. Richardson has just told us.

MR. GREENE: There seems to be an opinion current among a great many exhibitors that pure theoretical knowledge in the fundamental sciences, which has worked such wonders in other industries, is of no use and has no place in the motion picture theater. The cry has been for practical training to the exclusion of all else.

Now, it is very doubtful if any man ever lived who represented so high a type of the practical man as Luther Burbank. The text of one of the high points he believed was essentially this, "When you come to study one little narrow subject, whether it be bee culture or plant breeding or keeping house or operating a telephone switchboard, the more you know of physics, chemistry, and the other great fundamental natural sciences, the better you will be, because you will know how to relate and where to place all the facts which come to you. A fact out of place is not a fact at all." Now, Luther Burbank could not have spoken more directly had he been speaking to the projectionist alone, because innumerable instances arise in the projection room where only by a knowledge of the most fundamental sciences can the projectionist properly classify and relate isolated facts and logically reason through to the solution of a problem.

Mr. Richardson's remarks have dealt exclusively with the professional field, but there is another field of projection which if not of equal is of rapidly growing importance and where an even greater store of scientific knowledge is needed. This is the field of educational projection. There have been a number of papers presented before this Society taking both sides of the question of the value of motion pictures for teaching. From what I have seen of projection in educational institutions, I am convinced that this question cannot be settled until the standard of projection in a number of our largest institutions is raised to the very highest degree of excellence and then a survey made. The difference between the physiological reactions of

good and of poor projection represents by far the greatest single variable involved. Educational projection has a task different from, and more difficult than theatrical projection; it must be judged by different and perhaps higher standards, and nothing short of the very best is of any use whatsoever.

MR. MCGUIRE: Much of the material manufactured by the firms represented in this Society is really frozen capital until consumed as screen presentation. Film is shipped to Hollywood and elsewhere, carbons and so on are distributed as a finished product to be used in those little factories, the projection rooms of this country. Each projectionist is in effect a little manufacturer and the quality of the finished product which the public pays for depends upon him. We cannot make projection in quantities or take batches of it for testing and comparison as we do other products. Projection is created and consumed at the same instant in thousands of theaters throughout the world. If we wish to secure the best possible results, we must raise the standard of projection.

To raise the standard of projection, we must raise the standing of the projectionist. Theater owners and managers should properly recognize the work of good men; projectionist societies and the formation of educational committees by union locals must be encouraged; and we should make every reasonable effort to bring competent projectionists into this society. We already have a number of projectionists who are proving valuable members of our organization and are of more benefit to the motion picture industry than is generally understood. It is no exaggeration to class such men as engineers, but perhaps they are content to be called craftsmen. As such they are doing splendid work by developing craftsmanship, which is the necessary complement of the accomplishments of the scientist and engineer.

Some projectionists attend these meetings at their own expense, and others come here with their expenses paid by their employers. If theater owners and particularly the large circuits could realize how much they benefit by having their projectionists attend these meetings, I feel sure that more men would be here as official representatives of their firms. The skilled worker in any field seeks to secure better results and, if possible, at less cost. The projectionists who attend meetings of the Society of Motion Picture Engineers are men of the highest type who in a practical way are giving productions better projection and contributing greatly to the development of skilled men in this field.

The paper read by Mr. Richardson this morning and those he has delivered in previous years with such papers as those read today by Mr. Townsend and Mr. Gray are tremendously beneficial in bringing about better conditions in the motion picture industry. The society of Motion Picture Engineers organized and conducted on a purely voluntary basis to develop progress in this field has rendered invaluable assistance to the great industry of which we are a part. Nothing however, that the Society has accomplished has been productive of more good or shown more immediate and tangible results than the recognition it has given to projectionists and projection.

DR. MEES: I think that nobody who has listened to Mr. Richardson on this and other occasions can have any doubt as to the importance of the projectionists' work. The question before us, which he has brought up again so well at this meeting, as to what can be done to improve the status of the projectionists is equally important. Hitherto he has had to learn his trade by a rough apprenticeship, and the hard and self-sacrificing labors of men like Mr. Richardson are well known to you. That is not the condition that the trade should be in. With the eclipse of the apprenticeship system of the middle ages there came the necessity in all the trades and professions—as these developed from the trades—for something to take the place of the apprenticeship system. It was obvious that as the trades became technical, they could no longer be learned by watching someone else doing them. Not long ago the doctor learned his profession that way. That has been replaced first of all by the hospital medical schools of fifty years ago and now by the elaborate medical universities. When the printing crafts in Europe gave up their apprenticeship system, as they did about thirty years ago, they established trade schools, and these trade schools have to a large extent replaced the old apprenticeship system. It seems to me that the projectionists must require sooner or later that the members of their unions shall be qualified men, and there must be established somewhere or other training schools where men can be taught the art of projection.

It seems to me that what we really want is a two years' course in a Mechanics Institute, for instance, with one year of optics and one year of general physics. This should be a qualification for membership of the unions. It would be necessary to accept the existing projectionists but to require a qualification for new membership, including proper training in the art of projection, before a man is allowed to be called a projectionist.

MR. BRIEFER: I move that this Society appoint a committee to

formulate plans and report on the advisability of forming a projectionists' section of this Society. In this way we may be able to localize information without loss to ourselves and help these men before we obtain these special institutions for the purpose.

PRESIDENT COOK: I am sorry to say your motion is out of order. Business of this sort must be originated by the Board, which has the administrative action of the Society in hand.

MR. RICHARDSON: I think I feel better this morning than I have for many years. I have conducted a discouraging fight for many years to get the industry to realize the importance of projection. When a man of the caliber of Dr. Mees sees the importance of this matter, and Mr. Greene, Mr. Townsend, Mr. Gray, and others representing the projectionist express their interest by attendance at our meetings, it is a tremendous encouragement to me.

MR. MCGUIRE: There are some very practical difficulties in the way of apprentice systems. All I believe we are asking this Society and the firms to do is to do exactly what the Kodak Company is doing—employ intelligent men to co-operate with them and support them.

MR. RICHARDSON: Mr. McGuire is quite right in a way, but I am firmly convinced that the only way to get really practical results is to sell projection to the exhibitor himself. When this has been done, what Dr. Mees has said and all the rest of it will come about. When we shall have convinced the exhibitor that expert knowledge and high grade intelligence is sufficiently necessary in his projection room that it will pay him to have it, the rest will follow.

DR. MEES: Of course, this is a matter of procedure, a question as to which is the best way to get what we want. Mr. McGuire's idea is that we should get the exhibitors to change their hearts. The attitude of the exhibitor toward the projectionist has been dependent on that which the projectionist showed toward the exhibitor. When the projectionist would work for anything, the exhibitor despised him and ill-treated him. When the projectionist got into unions, held up the exhibitor, he no longer despised him but disliked him; but when he saves money and does a good job, the exhibitor respects him. If the teachers and the unions work together to ensure that the projectionist is a man of standing, then the exhibitor will treat him as one.

What we have got to do to get this done is to get the idea sold to the unions and to those who control the great chains of theaters. If we can get the theater owners to require a standing in their projectionists and on the other hand get the projectionists to require a

standing in those they admit to their ranks, then there will be no trouble with the exhibitor.

PRESIDENT COOK: With his usual keen analysis, Dr. Mees has indicated a plan which has been sought so long by our Society and particularly by the preponderance of projection interests therein. It depends entirely upon the projectionist himself and his ability to impress the exhibitor and upon the exhibitors' respect for the projectionist founded on his qualifications, and Dr. Mees has pointed out a workable method of getting this which will solve the whole problem when completed.

MR. TOWNSEND: I should like to agree with Mr. Richardson that the idea is to sell projection, and I agree with Dr. Mees at the same time that we must have projection to sell before we can sell it. I believe it will be hard to get many of the unions to make the requirement that Dr. Mees suggests. I think that will be the hardest problem; it will be necessary to make them see the necessity for having the best possible men first.

MR. RICHARDSON: Would not the President, under the circumstances, admit a motion that a committee, consisting of the President and such other members as he may think best, be appointed to lay this whole matter before the Hays organization in an endeavor to have that body use its great influence to impress and influence the exhibitor himself? Mr. Hays and his organization are able to reach the exhibitor and wield a powerful influence over him, and I believe they would be willing to do so were this matter properly laid before them.

PRESIDENT COOK: The Chair must sustain the by-laws and must rule the matter out of order.

DR. HICKMAN: May I ask on behalf of the meeting whether or not at all times a member can put an idea before the meeting, or must he communicate in private with the Board?

PRESIDENT COOK: Any ideas can be presented on a subject pertinent to the meeting, but the Society as a whole cannot receive or entertain motions which have to do with the administrative functions of the Society. That has been delegated by the Society to the Board. Much time better devoted to papers was formerly frittered away by irrelevant discussions. It is only by the delegation of authority to a few individuals in whom you have confidence that time can be conserved and the efficiency of the Society maintained. If the Society wishes to go back to the old method of administration, they have only to so alter the constitution and the by-laws to permit it. At present the Chair must enforce these laws.

AN IMPROVED CONDENSER SYSTEM FOR MOTION PICTURE PROJECTION

LEWIS M. TOWNSEND*

AT PRESENT there are four types of illumination in general use for motion picture projection. They are as follows:

1. The straight arc with $4\frac{1}{2}$ -inch diameter condensers.
2. The mazda lamp with condensers.
3. The high intensity arc with $4\frac{1}{2}$ -inch diameter condensers.
4. The low intensity reflector arc.

Because of its great efficiency, the low intensity reflector is rapidly displacing the old style straight arc. It is probable that this type of illumination will be popular for some time to come because of its economy in both carbon and current consumption. The mazda lamp fills a very good field in schools, churches, small theaters, and in many of our screening rooms, theaters, etc. The low intensity reflector arc has its limitations in that its efficiency falls off very fast when more than 30 amperes are used. For that reason it is not suitable for many of the very large theaters. In these cases it is necessary to resort to the high intensity arc for light source. This in combination with $4\frac{1}{2}$ -inch diameter condensers gives fairly good results as to amount of illumination but leaves much to be desired in the way of clearness of field. In other words, in the majority of cases the center of the screen is very bright, but the intensity falls off rapidly toward the edges. There is also considerable trouble in keeping the field white at all times.

Why are $4\frac{1}{2}$ -inch diameter condensers used? When the motion picture projector was invented, a condenser $4\frac{1}{2}$ inches in diameter was used which was then just large enough to cover the standard lantern slide, which is $3\frac{1}{4} \times 4$ inches. These condensers were available and apparently the projector was built around this. Had it not been for this, the condenser diameter for motion picture projection might easily have been 3 or 10 inches. One reason why larger condensers have not been developed in later years has been that the excessive heat caused considerable breakage. New developments in the past two or three years have eliminated this difficulty. There is now available a heat resisting glass, and I am informed that the leading lens manu-

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facturers are now able to guarantee condensers against breakage. With this in mind about two years ago, November 11, 1925, to be exact, the matter of larger condensers was taken up with Mr. Sander Stark.*

Since that time several combinations and sizes have been tried. What proved to give the best results was a new condensing system

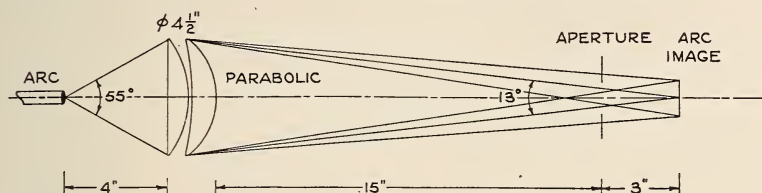


Fig. 1. A typical $4\frac{1}{2}$ -inch diameter condenser system set-up.

using a $6\frac{3}{8}$ -inch diameter collector lens and a $7\frac{1}{4}$ -inch diameter parabolic converging lens in combination with a relay condenser system. This entire system was designed and developed by Mr. Stark. Referring to Fig. 1 which shows a typical $4\frac{1}{2}$ -inch diameter condenser

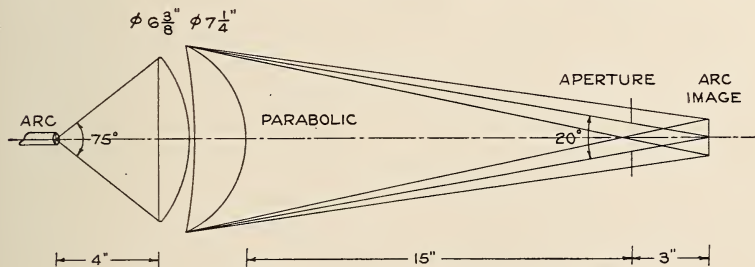


Fig. 2. A new condenser system set-up.

system set-up. This consists of a $7\frac{1}{2}$ -inch focus collector lens and a parabolic converging lens.

With the arc 4 inches from the rear condenser, a light angle of 55° is taken in by placing the front condenser 15 inches from the aperture. In this case an arc image is formed 3 inches ahead of the aperture. This I believe to be the best possible set-up for this type of condenser for use with a $6\frac{3}{4}$ -inch equivalent focus objective lens.

In the new system shown in Fig. 2, the collector lens is a plano-convex condenser $6\frac{3}{8}$ inches in diameter. The converging lens is

* Scientific Bureau, Bausch & Lomb Optical Company.

parabolic and $7\frac{1}{4}$ inches in diameter. The equivalent focus of this combination is such that the same working distance between the arc and collector lens, namely 4 inches, is maintained. This gives us a light angle of 75° . The distance from the converging lens to the aperture remains 15 inches, and the light image is again 3 inches ahead of the aperture. Table I gives us the apparent screen brightness as taken in each case over an average of 12 readings. A Macbeth Illuminometer was used for the tests.

TABLE I
Without Relay

Condenser	Brightness	Amperes	Volts	Carbon Size
$4\frac{1}{2}$ -inch Diameter	17.1 F.C.*	100	60	13.6 mm.
New Condenser	26.6 F.C.	110	60	13.6 mm.
New Condenser	25.5 F.C.	78	52	11.0 mm.
New Condenser	24.5 F.C.	65	52	9.0 mm.

*F.C. = Foot Candles.

Particular care was taken in each of the tests to maintain a steady arc at as near the given amperage and voltage as possible. This shows that with a $4\frac{1}{2}$ -inch diameter condenser set-up an apparent screen brightness of 17.1 foot candles is obtained. With a new condenser set-up using the same carbons and amperage, an apparent screen brightness of 26.6 f. c. results. This is approximately a 55% increase. With this same set-up using 11 mm. carbons at 78 amperes and 52 volts, we obtain an apparent screen brightness of 25.5 f. c. which is about 50% increase over the $4\frac{1}{2}$ -inch diameter condenser at 110 amperes. Again, with the new 9 mm. high intensity carbon, which has just been developed, at 65 amperes and 52 volts the apparent screen brightness is indicated as 24.5 f. c., this being about 43% increase over the $4\frac{1}{2}$ -inch diameter condenser at 110 amperes.

Fig. 3 shows a $4\frac{1}{2}$ -inch diameter condensing system set-up with relay condenser.

The same conditions prevail as in Fig. 1 except that the lamp house containing the arc and condensers is moved back 8 inches. In this case the arc image is formed on a relay lens placed 18" from the front of the condenser. The relay lens is 5 inches from the aperture. The aperture lens again forms an arc image 6 inches ahead of the aperture. Fig. 4 shows a new condensing system set-up with relay condenser.

In this case the first arc image is again formed just 18 inches ahead of the front condenser on the relay lens, but in order to image

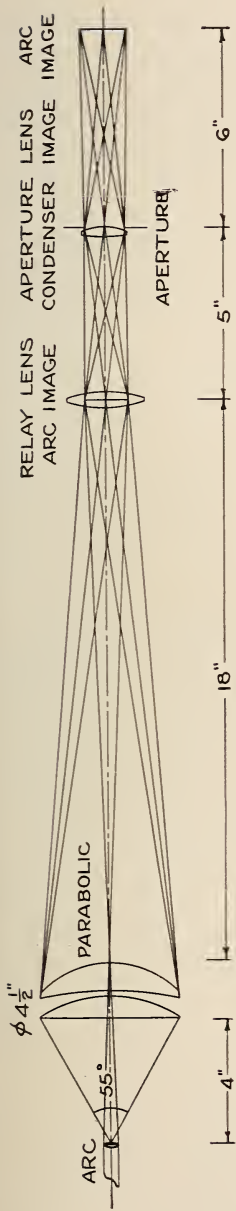


Fig. 3. A 4½-inch diameter condensing system set-up with relay condenser.

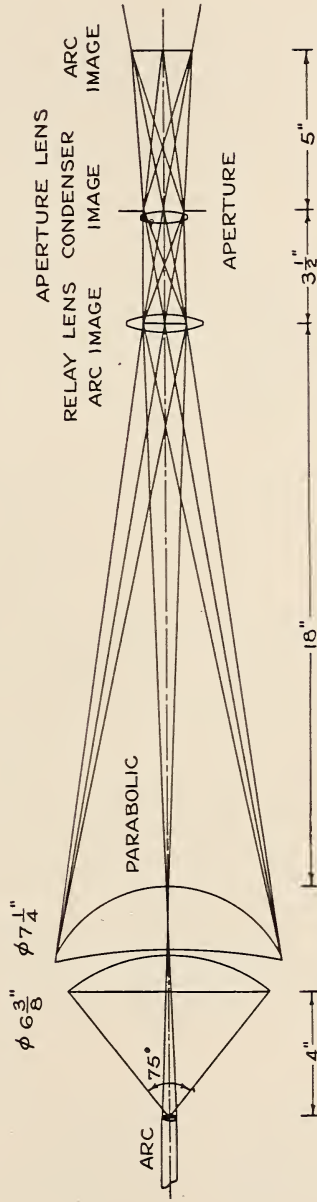


Fig. 4. Schematic drawing of new condensing system set-up with relay condenser.

the larger condenser diameter at the aperture, a slightly shorter focus relay lens and a slightly shorter focus aperture lens is used and an arc image is again formed 5" ahead of the aperture. With these two set-ups and with the same conditions prevailing as indicated in Table 1, the following apparent screen brightness readings are obtained.

TABLE 2

With Relay

<i>Condenser</i>	<i>Brightness</i>	<i>Amperes</i>	<i>Volts</i>	<i>Carbon Size</i>
4½-inch Diameter	13.4 F.C.*	110	60	13.6 mm.
New Condenser	19.2 F.C.	110	60	13.6 mm.
New Condenser	18.1 F.C.	78	52	11.0 mm.
New Condenser	16.1 F.C.	65	52	9.0 mm.

*F.C. = Foot Candles.

With a 4½-inch diameter condenser at 110 amperes and 60 volts the brightness was 13.4 f. c. With a new condenser system set-up with the same amperage and voltage the brightness was 19.2 f. c., and 18.1 f. c. with 11 mm. carbon at 78 amps. and 52 volts. With the new 9 mm. carbon at 65 amps. and 52 volts the reading was 16.1 f. c.

Noting the readings given in Table 1 without relay and Table 2 with relay, it is seen that apparently a much greater screen brightness is obtained without the relay. In reality this is not true. It is very interesting to note that if instead of taking readings to include the whole screen, the measurements are made at closer range starting at the center and moving outward toward the corner, then without the relay there is an average falling off in apparent screen brightness of about 25%. With the relay condensing system this does not occur. In fact the falling off in this case is less than 1 f. c. at the very corner of the screen. With this fact in mind, readings were taken under the same conditions as indicated in Tables 1 and 2 and the following readings obtained without relay:

TABLE 3

Without Relay

<i>Condenser</i>	<i>Brightness</i>	<i>Amperes</i>	<i>Volts</i>	<i>Carbon Size</i>
4½-inch Diameter	13.1 F.C.*	110	60	13.6 mm.
New Condenser	20 F.C.	110	60	13.6 mm.
New Condenser	19.1 F.C.	78	52	11 mm.
New Condenser	18.4 F.C.	65	52	9 mm.

* F.C. = Foot Candles.

With a $4\frac{1}{2}$ -inch diameter condenser, using a 13.6 mm. carbon and 110 volts, the screen brightness was 13.1 f. c. With the new condenser set-up using the same carbon and amperage it was 20 f. c. With the 11 mm. carbon at 78 amps. and 52 volts it was 19.1 f. c., and with the new 9 mm. carbon at 65 amps. and 52 volts it was 18.4 f. c.

I have given Table 1 because it is quite common to read the apparent screen brightness in this way, but Table 3 indicates the correct way of obtaining the total screen brightness when there is so much falling off from the center. The only proper way at present to utilize the high intensity arc is in combination with the relay condenser system. Table 1 is given for the benefit of those in the business who insist on every particle of light available being projected to the center of the screen and who do not care whether or not this brightness falls off considerably towards the sides. With a relay, the screen remains at practically the same brightness at all points. It is always clear with no yellow corners ever showing and no indication is given of flickering of the light or rotation of the crater image.

DISCUSSION

MR. RICHARDSON: What is the effect of the relay lens on the possible reduction of the diameter of the spot? How do these lenses stand up under the heat? As long ago as ten years one correspondent of my department experimented with relay lenses but could not find one which would stand up under the heat.

MR. TOWNSEND: I have two relay lenses: a Bausch & Lomb and one made by Roger M. Hill, which he calls the "tandem." Mr. Hill doesn't use the aperture lens. I have never had one break. I can take it out and drop it on a cold piece of metal and it will not crack. It never gets so hot that you can't take it out with your hand. All of our experiments were conducted under the worst possible conditions. We burned the lamps at the highest amperage for a half hour and then turned on the ventilating fan. I have never had any breakage with the relay system.

The size of the spot at the aperture is only about $\frac{1}{16}$ inch larger than the diagonal of the aperture.

We get some loss of light from added lens surfaces, but by being able to converge the light to a better advantage, we gain more than we lose from lens surfaces.

MR. KURLANDER: Is the system capable of completely filling a $2\frac{1}{2}$ -inch objective lens?

MR. TOWNSEND: You can make a set up so that it will, but I prefer to use an aperture lens that will not fill a $2\frac{1}{2}$ -inch objective. I converge the light so that with a $6\frac{3}{4}$ -inch lens I can get as much light on the screen with a Series 1 as I can with the Series 2 with the same light source.

MR. RICHARDSON: If you can change the focus at will under the conditions we have with distortion, you could get a reduction of lens diameter and increase the depth of focus; is this true?

MR. TOWNSEND: This is all true except that as soon as the light leaves the objective lens it spreads continuously; there is no aerial image ahead of the projector. We have a large diameter to cover.

MR. RICHARDSON: You can put the shutter immediately in front of the lens.

MR. TOWNSEND: That is a fact. When using a regular condenser set up, I used a cut-off blade of 104° ; with this I use one of 90° and cover the motion.

MR. KURLANDER: How do you account for the fact that you get higher illumination with smaller lenses than with larger ones using the same source?

MR. TOWNSEND: That is a mistake; I didn't mean to claim that I get more with a small lens, but I am able to converge all the light in it, whereas with the larger lens, I don't fill it. I can get the same result with a Series II that I do with a Series I objective.

DR. MEES: The novel point in this paper is the substitution of the new condenser system and not the relay system which has been discussed in the past. I should like to ask about the effect of the new condenser system as such. There is a gain from the increased solid angle; the only disadvantage I can see is that you get a larger beam in the projection lens. Without the relay system this will fill the outer zone of the lens and result in increased spherical and chromatic aberration. Without a relay doesn't it put a heavy strain on the outer zones for definition?

MR. TOWNSEND: I think that must be true, but I haven't been able to make as many tests in this direction as I would like to. With the advent of the reflector arc the manufacturers were compelled to improve the quality of the lens to take care of this point. I believe that the lenses on the market for use with the reflector arc would be satisfactory.

MR. KURLANDER: The object of collecting more light is to use more at the projection lens. How does this increase come about even with the relay?

DR. MEES: It comes about without the relay because with the ordinary system you don't fill the outer zone of the projection lens. Mr. Townsend's point is that with the mirror arcs they use larger solid angles than he does, and it is therefore perfectly good practice to use a larger solid angle with a condenser system.

DR. GAGE: One thing in optics, if understood, will clarify this situation. Suppose we look at the projector from the position of the screen, if necessary with a dark glass. With a large projection objective and when observed from the screen, there is the possibility that the objective aperture will appear to be filled completely from every point on the screen. This represents the absolute maximum illumination obtainable with the given light source and objective. In this case, the sharpness of the image will depend upon the correction of the objective, including the outer zones, which are so difficult to correct. If, on the other hand, only a part of the objective appears to be filled with light, it is evident that its entire area is not utilized for getting light to all parts of the screen. Different portions of the projection objective may be used to project on the different parts of the screen. If there is any lack of correction, it appears as a slight distortion of the image rather than a blurring of the image. One of the functions of the relay condenser is that the arc image occurs in the projection objective; consequently, no matter what part of the screen you view the projector from, you will see the same part of the objective throwing light in that direction, and if the arc is smaller than the diameter of the projection objective, you are using only the center of the lens and the rest is not used. If the system is skewed a little, instead of the arc image being in the center, it may be on one side. The large projection objective allows skewing without producing shadows on the screen. In many respects the two cases are like seeing things through a window; in one case the view comes through the whole window and but a small portion is used to image any particular point, and the other case is like projection through the window; only a small portion of the window is used but the entire area is used to project each point.

MR. TAYLOR: The discussion has not as yet brought out clearly the factors making for superiority of the condenser lens of larger

diameter. All condensing systems aim to collect and utilize a large amount of light, and the measure of the light collected is in "solid angle" or "numerical aperture" or "F number." It is possible to collect as much light from an arc source with a lens of diameter of 4 inches as with the larger one of 6 inches, but to collect the same light with the two sizes of lenses the arc must stand closer to the smaller lens, and if the arc is too close, there may be trouble from smudging (or burning) and breakage. Consequently, if the arc is moved back to reduce these troubles, the diameter of the lens must be increased in the same proportion to gather in the same solid angle of light. On the other hand, if the same arc distance can be satisfactorily maintained for a lens 6 inches in diameter as for one 4 inches in diameter, about twice as much light will be collected, and I gather that the paper reports the result of measurements showing a substantial gain in screen illumination after substituting a condenser of larger diameter.

MR. TOWNSEND: There is a limit to the closeness that we can come to the rear condenser, and in many cases in the larger theaters they don't use as short a focus as the $4\frac{1}{2}$ -inch condenser and use even an 8-inch or 9-inch condenser in the rear with the parabolic condenser and use a smaller angle of light than 50° . I figure that 4-inches is about as close as you can come with safety, and I desire to use the same distance in both cases.

In answer to Mr. Kurlander's question, I am in the category a little while ago mentioned by Dr. Mees. My knowledge of optics is limited. As I said in the beginning, I didn't make any claims for designing this system. I am giving the report, which I consider true and faithful, of the readings obtained. The readings on the screen are the same as the comparison of the $4\frac{1}{2}$ -inch lens with the reflector arc. I can't explain how we get it through the objective, but we had screen readings made very accurately. With the $4\frac{1}{2}$ -inch condenser I didn't make an effort to make a high screen reading, but endeavored to use average wattage, even and equal in both cases.

MR. TUTTLE: Did you experience any difficulty with the images of dust spots or dirt on the condenser or relay lens showing on the screen? I think it would be difficult to keep the surface as clean as necessary.

MR. TOWNSEND: I never had that trouble. The lens is slipped out and cleaned in the morning, and the shield around it prevents dust getting in. Oil or paraffin from the film runs off and might leave a residue, cutting down illumination a trifle; it is almost $\frac{3}{4}$ of an inch

from the lens. I have had trouble only from the condensers; when they first came out, they had bubbles in them which showed on the screen. I took this up with condenser manufacturers, and they are now making them without the bubbles.

MR. RICHARDSON: What is the effect of heat at the aperture?

MR. TOWNSEND: I use a mask (just ahead of front condenser) in proportion to the aperture and cut it off so that the light just comes within the aperture. After running a two-hundred foot reel, there is no heat on the plate. I don't know that it makes any particular difference on the film.

THE LUBRICATION OF MOTION PICTURE FILM

BY J. I. CRABTREE AND C. E. IVES*

WHEN freshly developed or so-called "green" motion picture film is passed through a projector, there is a tendency for an incrustation to accumulate on the aperture plate or tension springs which retards the free passage of the film through the machine. Chemical analysis has shown that this incrustation consists largely of gelatin with more or less silver, dirt, and oil, but it contains usually only a trace of the metal or alloy of which the gate is composed.

The effect of the incrustation is to increase the friction between the metal parts of the gate and the gelatin coated surface of the film. This causes excessive strains on the edges of the perforations at the pull-down sprocket which ultimately results in torn perforations and therefore a diminished projection life of the film.

It is possible to reduce considerably the tendency for the formation of the gate incrustation by suitable lubrication of the film surface. This is accomplished usually by the application to the edge of the film of a thin line of paraffin wax which melts under the heat of the projector and forms an effective lubricant. However, the wax tends to wander over the picture area if applied in excess, and particularly in the case of sound record films this is very objectionable.

It is the object of this paper to discuss the various methods of lubrication employed to date and to indicate a new method which is equally satisfactory for sound record and ordinary motion picture films.

Factors Affecting the Ease of Passage of Motion Picture Film through a Projector

The facility with which the film passes under the pressure springs in the projector gate depends on:

1. The physical condition of the gelatin coating of the film.
2. The conditions to which the film is subjected in the projector.

1. If motion picture film is examined under a microscope by reflected light, it is seen that the gelatin surface, even in the region which is relatively free from silver, is covered with innumerable extrusions (see Fig. 1, magnification 540). The roughness of the

* Communication No. 330 from the Kodak Research Laboratories.

surface is much greater in the vicinity of the silver image (see Fig. 2, magnification 790) and if the latter is toned with iron or uranium the roughness is still greater (see Fig. 3, magnification 790). This is as

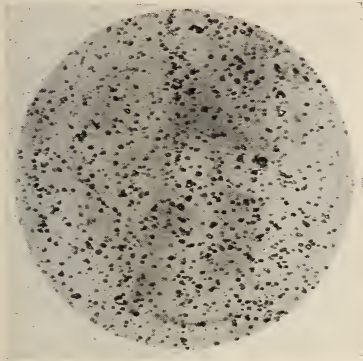


FIG. 1. Clear area of film.

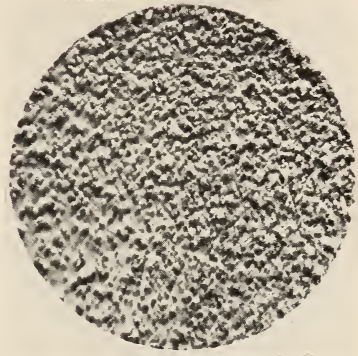


FIG. 2. Area in region of silver image.



FIG. 3. Silver image toned with iron ferrocyanide.

Photomicrographs showing appearance of surface of motion picture film by reflected light.

would be expected, because the toning process intensifies the image by virtue of the deposition of iron or uranium ferrocyanide around the silver grains composing the image and thus enlarges them.

It is possible to smooth the film surface either by grinding away or burnishing down the minute projections or by filling up the crater-like depressions. The effect of burnishing and of filling up the

depressions with wax and then burnishing or polishing is strikingly shown in Figs. 4, 5, and 6. Fig. 4 shows the surface of untreated film (magnification 540). Fig. 5 shows the same film after burnishing and Fig. 6 after applying wax and burnishing.



FIG. 4. Untreated film.



FIG. 5. Burnished.

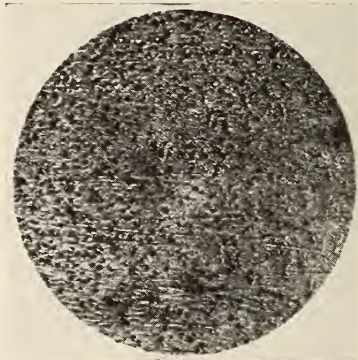


FIG. 6. Waxed and burnished.

Photomicrographs showing effect of burnishing, and coating the film surface with wax and then burnishing.

Tests have shown that the act of burnishing or polishing the film surface without the application of a lubricant such as wax or oil does not appreciably facilitate the passage of the film through the projector gate. It is well known, however, that film which has been projected once or twice has a much less tendency to produce an incrus-

tation on the gate than "green" film, and this is usually attributed to the burnishing or polishing action of the aperture plate or pressure springs on the gelatin coating of the film. The burnishing effect produced by projecting the film in a Simplex projector ten times is very slight, as shown in Fig. 7 (magnification 540). This is a photomicrograph of the film surface in the region between the perforations. The lower half of the figure shows a portion of the film surface which was in contact with the aperture plate. The burnishing effect on the film surface is negligible.

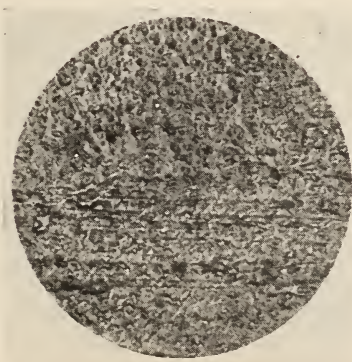


FIG. 7. Showing partial burnishing effect on film during projection.

It is considered that traces of oil which are transferred to the film surface during the first projection are chiefly responsible for the increased ease of passage of the film on subsequent projection.

It is obvious also that the moisture content and degree of hardening of the gelatin coating are important factors which determine the rate of formation of the incrustation in the gate. If the gelatin coating of the film contains an excess of moisture, it tends to soften and become "tacky" much more readily in the hot projector gate than is the case with dry film. This tendency of the gelatin coating to soften under the action of heat can be diminished by hardening during processing. However, excessive hardening tends to increase the brittleness of the film and is not to be recommended.

2. Apart from the condition of the film, the following factors relating to the conditions existing in the projector also determine the extent of the formation of the gate incrustation.

A. *The tension of the gate springs.* This should be of the order

of 8 ounces for each spring or a total of 16 ounces. The spring tensions should be adjusted individually at intervals by attaching a spring balance to the upper end of a narrow film strip placed at one side of the gate and increasing or decreasing the gate tension until the film just commences to travel upwards when the spring registers eight ounces with an upward pull.

In a like manner the tension with full width film should be adjusted to sixteen ounces.

B. The nature and smoothness of the gate surfaces. The nature of the gate material in contact with the film surface, providing it is of sufficient hardness, is of less importance than its degree of smoothness. Satisfactory materials are cast iron or stainless steel, either plain or chromium plated. Corrosion should be carefully guarded against and any gelatin incrustation removed with a wood or bone scraper so as not to scratch the polished surface.

C. The temperature existing at the gate. As explained above, the tendency of the gelatin to incrust on the gate springs in the case of freshly processed film increases with temperature. Any means of reducing gate temperature, such as the use of heat absorbing glass, a blast of air impinging on the gate, or suitable radiating fins on the gate, is desirable.

Methods of Facilitating the Passage of Motion Picture Film through the Projector

Even though a projector is in good mechanical condition and the above requirements are fulfilled, there is invariably a tendency for a gate incrustation to form with "green" film. Numerous methods of treating the film to offset this have been suggested from time to time as follows:

1. *By Edge Burnishing the Gelatin Surface.* It was considered that if the burnishing effect of the gate springs on the gelatin coating of the film could be simulated by a preliminary treatment, the difficulty caused by incrustation might be diminished. Accordingly, a machine was constructed for burnishing the edges of the film (see Fig. 8) consisting of a highly polished undercut roller (R_1) working against the edges of the film and revolving above an idler roller (R_2). The film was fed between rollers R_1 and R_2 by means of a gearing so arranged that the film advanced through a distance of $1/80$ th the circumference of the roller R_1 for every revolution of

the latter. It was possible to adjust the pressure on the burnishing roller by means of adjustable screws.

With undeveloped film an appreciable degree of burnishing was observed to take place, but with film fixed in a hardening bath the effect was very slight. Moreover, in view of the slight buckling of the film around the perforations, it was necessary to exert considerable pressure on the burnishing roller in order to flatten out the film

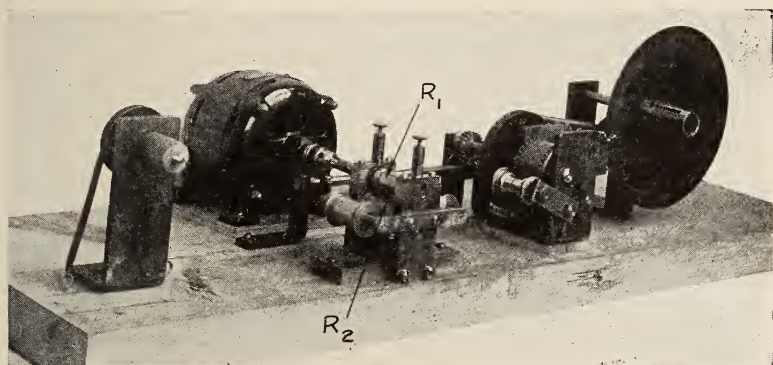


FIG. 8. Film burnishing machine.

so as to insure perfect contact. As a result of this pressure, a considerable amount of heat was developed, so much so that after the passage of a few feet of film, the gelatin coating commenced to grind away and particles of gelatin accumulated on the burnishing roller, stopping the machine. In order to prevent this it was necessary to apply a thin film of grease or oil to the burnishing roller which reduced the friction and prevented the grinding away of the gelatin.

In order to determine the precise effect of the burnishing apart from the effect of the grease, a roll of film burnished with the aid of automobile grease was passed through the projector, and a similar roll was merely treated along the edges with the grease. Since no difference was observed between the projection life of the two films, it was concluded that a mere application of oil or grease was just as effective as burnishing.

Experiments were made also with a heat burnisher consisting of a highly burnished roller working above a second roller and between which the film was passed with the gelatin surface in contact with the burnished metal. If the roller was heated to a temperature at which

a drop of water sizzled on the metal, a satisfactory degree of burnishing was effected although this treatment did not materially prolong the life of the film on projection.

2. *By Edge Lubrication.* Before the advent of more refined machinery for the purpose, it was customary to apply a layer of wax to the edge of the film during rewinding by passing the film face downwards over two blocks or candles of hard wax separated by a distance equal to the width of a picture frame. Although effective from a lubrication standpoint, with such an apparatus it is difficult to control the quantity of wax applied because this depends on the temperature of the wax, the pressure applied, and the rate of travel of the film. Usually the tendency is to apply too much wax, which then encroaches on the picture area and causes dark spots or patches on the screen. An excess of wax is also apt to cause projector trouble as explained below.

A suitable machine for applying a thin line of wax along each edge of the film surface and between the perforations has been described by J. G. Jones.¹ This consists essentially of two parallel thin steel discs separated by a distance of $1\frac{3}{32}$ " rotating in a vertical plane. The discs dip into a bath of molten paraffin wax and apply the wax to the film at their upper edge. The quantity of wax applied is controlled by the thickness of the discs, the temperature of the molten wax, and the rate of travel of the film.

Precautions to be Observed when Edge Waxing

The above method of lubrication is entirely satisfactory providing the wax is applied correctly, and no better lubricant than paraffin wax is known to date. However, if the temperature of the molten wax is not sufficiently high during application, too much wax is applied by the discs, and this does not solidify sufficiently before the film is rewound. This causes the wax to cement the edges of the film convolutions so that on rewinding, particles of wax are torn away from the film and these tend to encroach on the picture area, causing spots and blotches on the screen. This is harmful, particularly in the case of film with an edge sound record.

Another very serious danger resulting from the application of an excess of wax arises if the projector is threaded while hot with

¹ "A Film Waxing Machine" by J. G. Jones, *Trans. Soc. M. P. Eng., No. 15, 251* (1922).

newly waxed film. As the projector cools, the wax solidifies and holds the film so tightly that on starting the projector, the intermittent sprocket may tear out the perforations instead of pulling the film down through the gate. Since the fire shutter opens immediately when the projector starts, more or less film is apt to be burned up if the film does not start to move down promptly past the aperture.

A series of practical tests were made in this connection to determine the exact conditions under which candle edge waxing or Eastman edge waxing tends to cause the above trouble.

Film was first waxed with a waxer of the candle type which normally applies an excessive quantity of wax. After focusing the light ray from a 30 ampere reflector arc on the aperture opening of a Simplex projector for 30 minutes, this projector became heated to a temperature which would normally exist after the projection of a reel of film. Film waxed in the above manner was then threaded in the heated projector and left to cool for forty minutes. After cooling for such a period the projector had attained room temperature and any wax in the gate had hardened. On starting the projector, the intermittent sprocket tore through the perforations leaving the film stationary in the gate. Upon examination of the samples, it was found that the wax had softened and collected in the perforations and had cemented the film to the film tracks and the pressure springs.

The possibility of this difficulty occurring when film was waxed with the Eastman waxer was then determined. The projector was cleaned thoroughly, and a one thousand foot reel of film waxed with the Eastman waxer was projected in the normal way. Immediately after projection the projector was threaded with a length of unwaxed film and allowed to cool. When the projector was started the film pulled down through the gate with no difficulty. Several thousand foot rolls were then waxed with the Eastman waxer and projected in thousand foot units, each reel being run through the projector only once. After the projection of each reel the projector was threaded with unwaxed film allowed to cool, and then started. No trouble was experienced until seven thousand feet had been projected, when enough wax had collected to hold the film from being properly drawn through the gate. After the projector had been cleaned, it was possible again to project several thousand feet of waxed film before enough wax collected to cement the film, but after each 8,000 or 10,000 feet, the trouble was almost sure to occur.

Tests were then made to determine the quantity of wax which could be put on the film before it could be classed as waxed film, which would cause trouble by sticking in the projector. Several strips of film were prepared by waxing on the Eastman waxer, once, twice, three times, etc. In this way film coated with a known quantity of wax was obtained. The projector was then thoroughly cleaned, heated for thirty minutes, and threaded first with film which had been waxed once and allowed to cool. This procedure was followed with the film waxed twice, three times, etc., successively until indications of sticking in the gate were discovered. Repeated tests showed that trouble was not likely to occur unless the film was waxed for five or six times and therefore contained five or six times the quantity of wax normally applied by the Eastman waxer.

The above experiments serve to emphasize the importance of applying the correct quantity of wax to the film and of removing at very frequent intervals any wax which accumulates on the projector gate.

Lubrication of the Entire Gelatin Surface of Motion Picture Film

At the outset it was considered that by coating the entire gelatin surface of motion picture film with a thin layer of a suitable lubricant, many of the objections to edge lubrication would be overcome. Also, if the coating could be made impermeable to oil, trouble from oil spots would be eliminated likewise.

The idea of lubricating the entire gelatin coating of the film is by no means new. A large number of patents have been granted for particular lubricating formulas which include the use of tallow, lard, spermaceti, stearic acid, sodium stearate in methanol, oil of turpentine, olive oil, cotton seed oil, linseed oil, petrolatum, a suspension of gypsum in methanol, beeswax, and paraffin wax.

Before the commencement of the experiments described below, the Dworsky Film Mfg. Co. was supplying a film buffing machine shown in Fig. 9. This consists essentially of a series of four or five cloth buffing wheels similar to those used for polishing electro-plated metals, which buffers rotate at a high speed in contact with the gelatin surface of the film. The film is pulled through the machine by means of two rubber covered rollers of the laundry wringer type, the machine being entirely sprocketless. (The lower application roller attachment was not originally fitted to this machine). Usually a little tripoli

(polishing powder) was applied to the buffers to produce more rapid polishing of the film surface.

Although it might be expected that this buffing treatment would tend to scratch the gelatin surface, this was not found to be the case.

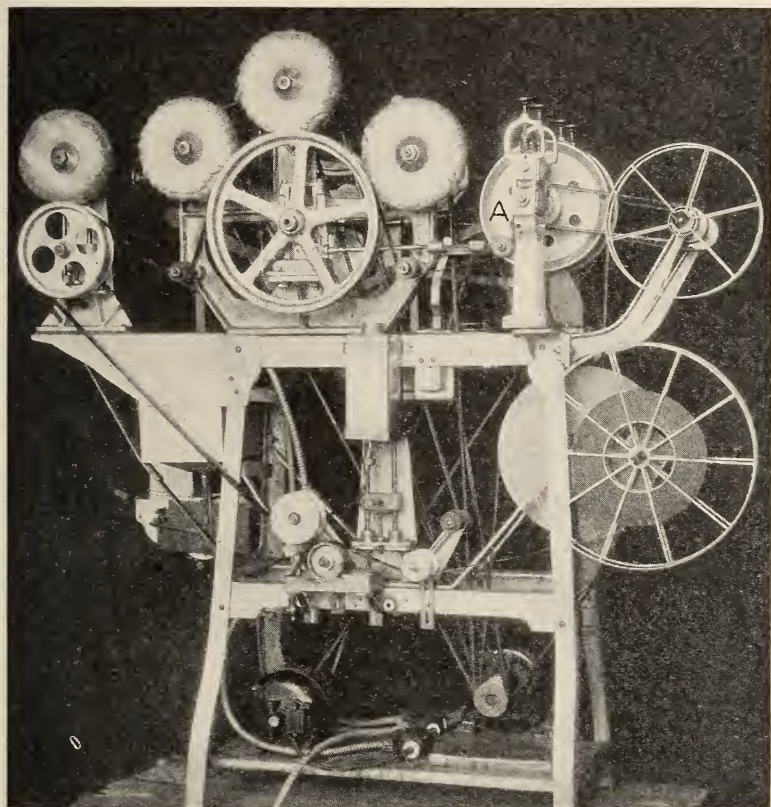


FIG. 9. Film waxing and polishing machine.

Instead, the treatment produced a noticeable gloss on the gelatin surface (see Fig. 5 as compared with Fig. 4).

Projection life tests made with buffed and unbuffed film indicated that the buffing treatment was of questionable value. However, the machine appeared to be readily adaptable for the application of lubricants to the entire film surface, and the following experiments were therefore made.

1. Machine oil or Russian mineral oil was applied to the entire gelatin surface and then buffed in the above manner. Projection tests indicated that film so treated had a projection life comparable with that of edge waxed film, although after storing in the rolled up condition for two or three days, the film developed oil spots. Attempts were made, therefore, to find a solid lubricant which would be impervious to the effect of oil.

2. Waxes were next applied to the film surface by holding a piece of solid wax against the first buffing wheel, which in turn applied the wax to the film. The remaining buffers then spread out the wax more evenly and imparted a high gloss to the film surface which resembled that of highly polished footwear.

Projection tests with film waxed in this manner with various waxes indicated that there is a wide difference in the lubricating quality of different waxes. Data regarding this will be given later. Oil treatment tests after waxing indicated that a surface coating of almost any wax over the gelatin surface of the film will materially reduce the propensity of the film to show oil spots on the screen.

Mechanical Methods of Applying Wax to the Film.

A. It was soon apparent that the above method of application of the wax was entirely impracticable and that a mechanical method of application was required. The application roller method of applying a solution of various waxes in suitable solvents was tried and this was ultimately entirely satisfactory.

The first arrangements of application rollers is shown in Fig. 10. The wax solution is contained in tank *T*, in which rotates a small flangeless aluminum roller R_1 covered with felt. Roller R_1 bears against roller R_2 , which is covered with silk plush. The film runs face downwards against roller R_2 and rotates it, and in turn this roller rotates the lower roller R_1 , which is immersed to a depth of about $\frac{1}{4}$ inch in the wax solution. By adjusting the distance between the rollers R_1 and R_2 , roller R_2 acts as a wringer and squeegees the excess wax solution from roller R_1 so that the quantity of liquid applied by the plush coating of roller R_2 can be regulated.

This method of application had the objection that the plush did not apply the wax solution sufficiently evenly, and it was not possible to control the quantity of wax applied with sufficient precision to insure against the wax solution passing through the perforations on to the base side of the film.

B. An entirely satisfactory mechanism for applying the wax solution is shown in Fig. 11. The film passes gelatin side downward

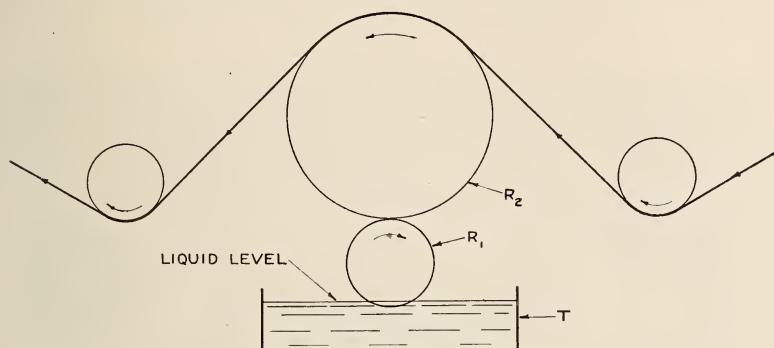


FIG. 10. Showing method of application of wax solution to film surface.

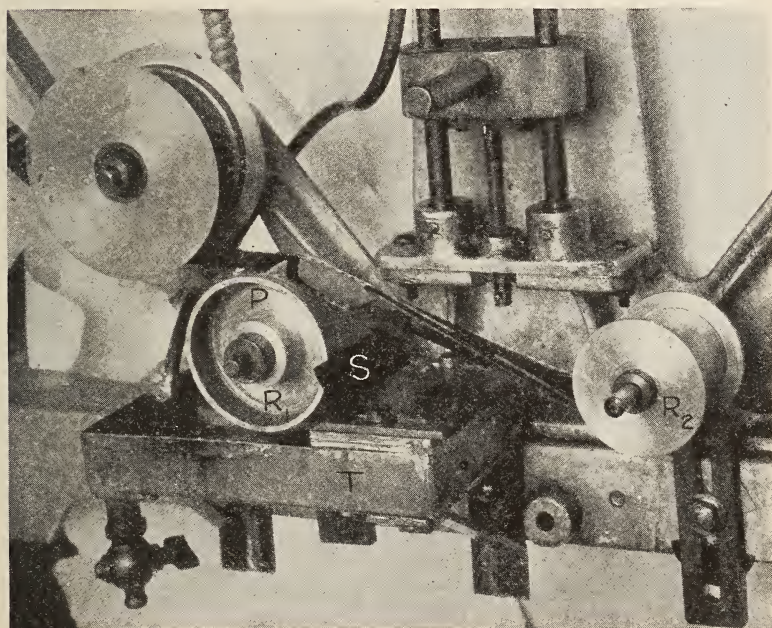


FIG. 11. Application roller for applying wax solution.

over the polished aluminum roller R_1 (about $2\frac{1}{2}$ inches diameter), which dips in the wax solution at room temperature in tank T to a depth of about $\frac{1}{4}$ inch. The excess wax solution is removed from the

surface of the roller by means of a "doctor" *S* consisting of a sheet of thick paper or ordinary motion picture film. This leaves an extremely thin layer of wax solution on the roller which is applied to the film

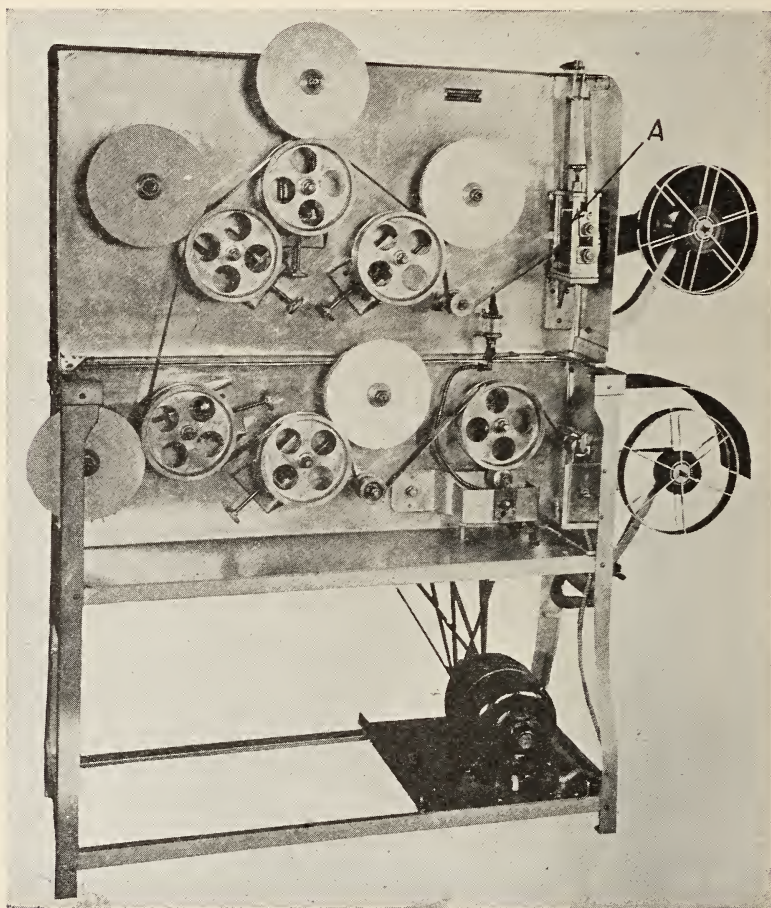


FIG. 12. Improved type of waxing and polishing machine.

surface at *P*. The friction between the roller R_1 and the film is sufficient to drive the roller R_1 without danger of slippage. This friction can be increased by lowering the idler roller R_2 in relation to roller *P*.

The latest type of Dworsky buffing machine is shown in Fig. 12. This is shown fitted with application rollers as first developed by the

authors. It is suggested that the single application roller shown in Fig. 11 be fitted to the new type machine.

Manipulative Details

Although at first sight the waxing machine appears somewhat complicated, it is very simple to operate, does not get out of adjustment, and requires little or no attention other than changing of the reels. The level of the wax solution is maintained constant by means of an inverted bottle or can be fitted with a tube dipping into the tank of liquid. The depth of the liquid is then at all times equal to the distance between the tube orifice and the bottom of the tank which holds the liquid. The film travels at the rate of 6 to 12 inches per second, the 6-inch speed giving a more desirable polish to the film surface. A roll of 1000 feet is, therefore, waxed in from 15 to 30 minutes.

About 2 ounces of liquid are required per 1000 feet of film providing the exposed surface of liquid in the tank is covered as far as possible to prevent evaporation.

The rubber rollers at *A* (Figs. 9 and 12) should be cleaned at intervals by holding a cloth moistened with carbon tetrachloride against the surface so as to remove traces of lint.

After waxing, it is desirable to rewind the film while passing it between the folds of plush so as to remove occasional particles of lint which tend to adhere to the film after polishing.

It might be considered that the film would ignite from the heat developed by friction perchance the film should remain stationary in contact with the rotating buffers. Tests indicated that the film did not fire after remaining stationary in contact with the buffers for 30 minutes.

Choice of Waxes and Solvents

The following waxes were tested: beeswax, cantol wax, candelilla, carnauba, Japanese, Johnson's floor wax, montan, hard paraffin, and Simoniz wax.

The choice of suitable solvents is somewhat limited because, as pointed out in a previous paper,² many solvents have a tendency to attack the silver image and are therefore unsuitable. The three solvents—benzene, gasoline, and carbon tetrachloride—were used in

² "Film Cleaning Liquids for Motion Picture Film" by J. I. Crabtree and H. C. Carlton, *Trans. Soc. M. P. Eng.*, No. 30, 277 (1927).

the preliminary tests. Since carbon tetrachloride is non-inflammable and when pure has no harmful effect on the film, this solvent was used exclusively in the later tests.

Properties of Motion Picture Film With a Coating of Wax over the Entire Gelatin Surface

1. The Projection Life as Compared with Edge Waxed Film

Comparative measurements were made on the projection life of the various samples of waxed film as follows: The ends of a 6-foot length of each sample of film were spliced together so as to form a loop, and this was run continuously through a Powers projector maintained as nearly as possible under standardized conditions. The gate spring tensions were checked at regular intervals, and the machine otherwise maintained in first class condition. If any incrustation tended to form in the gate, this was indicated by a distinctive noise and the incrustation was at once removed. The number of times which the film passed through the machine was recorded by a counting device, and projection of the film was continued until perforations became torn to such an extent that the film would no longer pass successfully through the machine.

Assuming a basis of 100% projection life for normally processed film which was not treated in any way before projection, the results of tests with films lubricated over the entire surface with various waxes were as follows:

<i>Nature of Wax or Oil Solution in Carbon Tetrachloride</i>	<i>Projection Life</i>
Plain film (untreated)	100%
Montan 1%	77
Montan 5%	94
Turpentine	100
Carnauba 5%	125
Johnson's floor wax 6%	185
Beeswax	260
Paraffin 1% (M. P. 130°-140°F.)	310
Paraffin 2 parts } Carnauba 1 part } 2%	380
Paraffin 2 parts } Carnauba 1 part } 5%	
Paraffin 5%	850
Eastman edge waxed film	950

The above results indicate that certain waxes, such as montan, can produce a negative lubricating effect and that the lubrication produced by all the waxes increases with the quantity applied.

Of the waxes tested, paraffin wax was the best lubricant and at a concentration of 5% was as satisfactory as Eastman edge waxing. However, a coating of pure paraffin wax was relatively soft and tended to show finger marks. Experiments were therefore made with a mixture of a hard wax (carnauba) and paraffin wax in the proportion of two parts of paraffin and one part of carnauba. Such a mixture gave a harder coating with a high gloss, but the projection life was about 40% less than that of plain paraffin. However, in practice the projection life of film is usually determined by factors other than the point at which the perforations break down. Film is frequently rejected on account of bad scratches before this point is reached, and it is therefore considered that the projection life of film treated with the carnauba-paraffin mixture is satisfactory.

2. The Tendency of Surface Waxed Film to Deposit an Excess of Wax in the Projector Gate

As mentioned previously, in the case of edge waxed film, there is a tendency for an excess of wax to accumulate in the gate so that on threading a warm projector and allowing it to cool, the wax cements the film to the gate so that it will not pass down through the gate on starting the machine.

Tests were accordingly made with film, surface waxed with a 5% solution of a mixture of two parts carnauba wax, and one part paraffin wax. Twelve 1000-foot reels were projected in succession through a Simplex projector without disturbing the gate. At the completion of the run, a piece of unwaxed film was threaded in the machine and the machine allowed to stand for one hour so as to cool thoroughly. On starting the cooled machine, the film was pulled down satisfactorily through the gate, showing that no serious quantity of wax had accumulated as a result of the projection of the twelve reels. Examination of the gate showed the presence of negligible traces of wax, but there was present a slight amount of "fluff" which was presumably deposited on the film from the buffing wheels.

In this connection the heated reels after projection were allowed to cool thoroughly and then rewound. No tendency for the convolutions to stick together was observed, and the possibility of this

happening is somewhat remote because the surface coating of wax applied to the film is extremely thin.

3. Effect of Surface Waxing on the Propensity of Film To Show Oil Spots on Projection

It is well known that when film accumulates oil in the projector, the effect of the oil is usually visible on the screen as patches of lesser density than the surrounding portion which is free from oil. The effect of clean oil is to fill up the tiny surface craters, thus reducing light scatter which results in an increased transparency of the film. In the case of dirty oil, or when dirt is applied to clean film treated with clean oil, the oil spotting is greatly exaggerated and such dirty oil produces dark spots.

A study of the surface structure of motion picture film (see Fig. 2) explains why it is difficult to remove oil by mere wiping. The oil sinks into the innumerable craters present on the surface and can only be removed by treatment with suitable solvents.

At the outset it was considered that a waxing treatment might insulate the gelatin surface from the oil and reduce the propensity for oil spots to show on the screen. This was tested as follows:

Film toned with a uranium toner was used for the test because such toned film has a maximum propensity to show oil spots, presumably because of the extremely pitted nature of the film surface. A reel of film was assembled consisting of fifty foot strips treated as follows:

<i>Sample</i>	<i>Nature of Film</i>
No. 1	Plain uranium tone
No. 2	Waxed with 5% paraffin in carbon tetrachloride
No. 3	Waxed with 5% solution of 2 parts paraffin and 1 part carnauba
No. 4	Waxed with 1% carnauba and overcoated with 5% paraffin
No. 5	Waxed with 1.5% candelilla and overcoated with 5% paraffin

Preliminary tests to determine the rate of solution of cold waxes and mineral oil indicated that carnauba and candelilla waxes were more impermeable to oil than paraffin, so that in the above double coated tests the object of the first coating of carnauba or candelilla wax was to protect the film against oil, while the coating of paraffin was to secure maximum lubrication.

A good grade of light machine oil was splashed in liberal quantities on all the samples while the film was being wound from one reel

to another. The film roll was then rewound twice, during which time the oil was smeared over the surface with a cloth. After this treatment the film surface presented a mottled appearance. The reel was then projected immediately and subsequently three times each day.

After the first day objectionable oil spots appeared on the unwaxed sample. At the end of one week no oil spots were visible on any of the waxed samples. It was concluded therefore that paraffin wax although miscible with oil prevents oil spots. In order to prevent oil spots it is apparently merely necessary to fill up the crater-like depressions on the surface of the film.

A roll of toned film treated with candelilla wax and then splashed with oil was prepared over a year ago and projected at frequent intervals up to the present time. No oil spots have appeared on this film to date.

4. The Tendency of Surface Waxed Film to Accumulate Dirt and Develop Scratches on Projection

Sufficient data have not as yet been secured to determine the effect of the surface coating on the propensity of the film to accumulate dirt and develop scratches on projection in comparison with untreated film. A projection test was made by applying dirt to the projector gate and by throwing the film on a dirty floor and then projecting. No appreciable difference in the quantity of scratches or dirt accumulated on the film was noticed between surface waxed and edge waxed film.

Data in this connection are being secured by circulating reels, half of which are surface waxed and one half edge waxed, through various exchanges.

5. The Tendency of Surface Waxed Film to Retain Moisture

It is well known that if the gelatin coating of motion picture film is deprived of its moisture content, the film tends to become brittle. The chief cause of brittleness of projected film is the loss of moisture as a result of repeated baking of the film in the hot projector gate.

It was considered that possibly the surface coating of wax might retard the evaporation of moisture from the gelatin, and this was tested by first humidifying a strip of film for one hour in an atmosphere at 90% relative humidity, surface coating one-half of the strip with wax, and then placing the waxed and unwaxed strips in a desiccator over night. No difference in brittleness of the two dried

out film samples was noticed. Apparently the wax coating on the film surface is so thin that it does not appreciably retard the rate of evaporation of moisture from the film.

Summary and Practical Recommendations

The projection life of motion picture film can be prolonged considerably by coating either the edges in the region of the perforations or the entire gelatin surface of the film with a thin film of wax. Edge waxing as now practiced by use of the Eastman edge waxing machine is an efficient means of lubrication providing it is done correctly, but if the molten wax is not heated sufficiently during application, there is a tendency to apply too much wax to the film.

This causes an excess of wax to accumulate in the projector gate so that if the freshly waxed film is threaded in a warm projector which is then allowed to cool, the wax solidifies and holds the film so tightly that on starting the projector the film remains stationary in the gate and, in the case of most projectors, then catches fire.

An excess of wax on the film also causes the convolutions of the film to adhere together when the film roll cools after projection, and particles of wax torn from the film during rewinding tend to settle on the picture area causing spots and unevenness on the screen. Edge waxing is also impossible in the case of film with an edge sound record.

By coating the entire surface of the film with an extremely thin coating of a suitable wax, or mixture of waxes and then buffing or polishing many objections to edge waxing are overcome. This may be done efficiently by applying a 2% solution of a mixture of carnauba wax and paraffin wax dissolved in carbon tetrachloride, by means of a suitable machine, which buffs the film surface to a high gloss after application of the wax. The exact proportion of carnauba and paraffin waxes is a matter of choice. A high proportion of carnauba gives a hard highly polished coating, while a high proportion of paraffin gives a softer coating with less gloss but with a greater lubricating value. The following formula containing equal parts of carnauba and paraffin gives a sufficiently hard coating with satisfactory lubricating qualities:

	<i>Metric</i>	<i>Avoir.</i>
Carnauba wax (M. P. 175°-185°F.)	10 grams	150 grains
Hard paraffin wax (M. P. 130°-140°F.)	10 grams	150 grains
Carbon tetrachloride to	1000 cc.	32 oz.

With this method of application it is practically impossible to apply a dangerous excess of wax to the film, so that the above difficulties caused by the application of an excess of wax are eliminated.

A film surface waxed in the above manner has also a minimum propensity to show oil spots on projection even when a liberal quantity of machine oil is applied to the film in the projector.

Practical tests have shown that the projection life of surface waxed and buffed film, as determined by the point of complete breakdown of the perforations, is not quite as great as that of edge waxed film. However, in practice, film is rejected usually for other reasons before the complete breakdown of the perforations, so that the projection life of surface waxed film is considered satisfactory.

Acknowledgment

The authors are indebted to F. J. Closser and L. E. Muehler, who assisted in the experimental work, and to R. N. Titus, who made the photomicrographs.

DISCUSSION

MR. CUFFE: With regard to the Eastman waxer, we have found with our prints going out that the operators complain that under high intensity projection there is not sufficient wax on them. We have increased the thickness of the waxing blade and still find that the emulsion piles up because the wax is put on in a straight line. With a snake-like line along the sprocket holes we overcame the trouble. I think it would be a good idea to make some tests on this.

MR. CRABTREE: How do you produce the wiggle; with an oscillating member?

MR. CUFFE: We offset the disk that distributes the wax.

MR. RICHARDSON: I must voice an objection to the method proposed which proposes to set each tension shoe at a predetermined pressure measured in ounces. It is highly important that the projector aperture tension be just barely sufficient to prevent the film over-shooting, and since projection speed varies in different theaters, any plan which predetermines the tension shoe pressure must of necessity be sufficient to prevent over-shooting at the highest projection speeds used in the theater where over-speeding projection is practiced. In other words, it must be sufficient to prevent over-shooting under the worst possible condition, which, of course, would be

much too high a tension pressure in theaters which do not over-speed projection.

Another thing to be considered is that not all projectors have the same number of tension shoes, which fact automatically sets up a complication.

Many years ago, upon observing the damage done to film by tension shoe pressure abuses, I devised a method for tension adjustment which was simple and entirely practicable. I have seen no method up to this time which I consider better or even as good. It consists in the projectionist speeding the projector to ten revolutions of the crank shaft above the maximum projection speed used in the theater, and so adjusting the tension that at that speed the screen image just begins to creep up—evidence that the film has begun to over-shoot. The thing requires no scale and can be applied by any projectionist or even by a machine operator of average intelligence.

As to the statement made by Mr. Gray this morning to the effect that film life is not dependent upon the sprocket holes, I must disagree with him even though it be true that other abuses may put film out of commission with reasonable frequency while the sprocket holes are still in good condition. Sprocket hole damage is usually caused by undercut and hooked sprocket teeth plus excessive aperture tension; also, by the use of excessive tension at the aperture in an endeavor to hold a picture steady on the screen when the cause of unsteadiness is worn or poorly adjusted projector mechanism parts. I am of the opinion that although Mr. Gray's statements about other sorts of damage to film are quite correct, still the useful life of film is shortened more by abuse of the sprocket holes caused by excessive aperture tension than by anything else.

MR. TOWNSEND: I should like to enter a mild objection to Mr. Richardson's remarks with regard to the amount of tension for the reason that it is possible for a projector to get in such condition that you must apply almost twice as much tension as Mr. Crabtree indicated in order to hold the film steady under certain conditions at the speed we require, and I think that if a measurement of the tension applied were made when you had to apply more than the stated amount, then the projectionist would know that something besides the tension was wrong. In the Simplex projector with the space between the film pressure plate and the aperture becoming too wide you must apply more tension, and I believe it is true that more tension must be applied to the shoes on the Powers projector than on the

Simplex. I may be wrong, but I think that by virtue of the difference in the construction of the two projectors there is a difference in the pressure. I hate to be considered among a great class of projectionists who are not able to apply this simple method of adjusting tension. I think they should be able to do that much.

MR. RICHARDSON: Mr. Townsend must remember that only a few projectionists have the facilities which he has.

MR. CRABTREE: All you need is a spring balance.

MR. RICHARDSON: If you undertake to ask the projectionist in many small towns to measure the pressure tension on a shoe, he will look at you with amazement. If you can show me any method that any man can readily apply, I will agree with you, but you must remember that a projector with two pads would be different from the Powers with six, and any man can run his projector at the maximum speed and set the tension so that the film just begins to crawl up.

MR. TOWNSEND: I should like to say that I was so dumb that when the thing was first proposed to me I called upon Mr. John Jones and asked him the simplest way to test it, not being able to get a small scale. He said: "Why not weigh a pound of lead or iron, hang it on a pulley, and loosen up the tension until it pulls it down?" I believe those methods have been described in the *TRANSACTIONS* from time to time, and as long as they have, we should apply them.

MR. RICHARDSON: May I ask you why the one I have proposed is not the simpler? What objection have you to the other method, which seems to me applicable by anybody very simply?

MR. TOWNSEND: The only thing is that projectors can get in such condition that two pounds of pressure are necessary to hold the picture steady at the speed required.

MR. ROSS: Mr. Townsend is trying to point out the fact that the spring balance method would indicate when a projector needs repairing, whereas Mr. Richardson's does not.

MR. RICHARDSON: Does or does not the wax coating have a tendency to accumulate dirt, which will in course of time impregnate the wax so that it cannot be removed? Also does the wax coating have any effect on the transmission of light, either as to the amount passed or in the matter of diffusion?

MR. CRABTREE: With regard to the propensity of the surface wax to accumulate dirt, I mentioned that we are making tests on this but they are not completed. It is difficult to get a comparative test. We took two pieces of film, waxed and unwaxed, and made them

dirty in various ways and didn't notice any difference. We are circulating treated film through the exchanges, half of it surface waxed and the other half edge waxed, to get reliable data on this point. I doubt if the wax surface will have a greater tendency to collect dirt. Paraffin is relatively soft, but we finally used a mixture of a hard wax like carnauba and paraffin.

With regard to the light transmission, the coating is so infinitesimally thin it has no effect on transmission nor does it affect the definition.

MR. BRIEFER: A few years ago I conducted some experiments on the same type of machine. This machine was described in a paper on the physical characteristics of motion picture film, but the experiments were never completed and never published. We tried various forms of wax and used one of the earlier type buffers with the cloth wheels. Finally, after a number of trials, we tried ordinary neutral soap dissolved in alcohol, and later sodium oleate was tried. Without attempting to predict anything in particular for the method, we think it very effective, and I bring it up now because Mr. Crabtree may wish to make further experiments.

MR. ISAACS: Is there any particular temperature at which the use of this solution is recommended?

MR. CRABTREE: Any temperature from 50°F. to 90°F; I don't think it makes any difference.

MR. BRIEFER: It remains quite cold, doesn't it?

MR. CRABTREE: The warmer it is, the more rapidly it will evaporate, but it doesn't have much chance to evaporate before it is applied.

AN EXPERIMENT IN THE DEVELOPMENT OF CLASS-ROOM FILMS

T. E. FINEGAN*

There are three chief reasons why motion pictures have not come into general use as an agency in classroom instruction. These are:

1. Few motion pictures adapted to classroom service have been produced.

2. The cost of the necessary equipment and the cost of production and distribution have rendered motion pictures prohibitive for classroom service.

3. Teachers generally are unfamiliar with the use of motion picture apparatus and with the use of film, and there is more or less feeling on their part that some embarrassment might follow an attempt to use them.

The production of a type of film for classroom use is purely an educational or professional problem. The cost of producing the necessary equipment and the cost of making and distributing films is purely an economic or business question. The training of teachers to use and to appreciate the value of films is a simple question of good school administration.

The general use, therefore, of classroom films resolves itself into the solution of these questions: Is it possible to produce the character of films which will yield measurable results in classroom work of sufficient value to make their use a profitable investment? If such films can be produced and this result can be achieved, is it possible to produce them at a cost which will make it practical and feasible for the schools to provide them? Can teachers be trained to use motion picture apparatus and to evaluate film service?

It may not be expected that motion pictures will be given popular recognition as a teaching agency by educational authorities until sufficient reliable data upon these vital questions are made available. A few experiments in this field have been conducted in this country and in Europe, but the extent and the general scope of such experiments have been wholly inadequate in the results recorded and in making available to the public material upon which a basis for the determination of these questions may be reached.

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The experiment under consideration was not entered upon in the belief that it would afford all the information desirable in the development of a sound program of visual instruction through the use of motion pictures. It was undertaken in the belief that it would reveal the essential fundamental knowledge for the solution of the chief questions which we have stated are the basis of the development of such program.

A brief statement of the movement which led to the experiment will give a better understanding of its purpose. In 1922 the National Education Association created a committee on visual education to develop plans which would extend the use of visual aids in the schools. This committee established coöperative relations with the Motion Picture Producers and Distributors of America, Inc. The purpose of the committee was brought to the attention of the Eastman Kodak Company.

In March, 1926, Mr. George Eastman announced that the Eastman Kodak Company had made a survey which showed in substance that little had been accomplished in the production of suitable films for classroom service; that there appeared little prospect that an organization with sufficient resources would enter upon a program to produce films of this type on an adequate scale; that motion pictures for this specific purpose were not practicable until an easily operated projector and economical films were available, but that he believed projectors on the market and the narrow width film would afford a solution of the economic aspects of this problem. This announcement stated further that in view of these conditions, and after full deliberation, the Eastman Kodak Company had decided to approach the solution of this problem by an experimental method; that under the advice and coöperation of leading teachers, the company would produce a number of classroom films closely correlated with selected courses of study and in accordance with a definite educational plan; that provision would be made to give these films adequate trial in classroom practice to determine their value for such use; and that through the results achieved it should be possible to reach sound conclusions on the effectiveness of films as a classroom aid, and also to ascertain the probability of producing such films at a cost which would make them available for popular classroom service.

Following this announcement, Mr. Eastman invited several leading teachers and school administrators from various parts of the

country to come to Rochester for a conference at which he presented the general plan of the proposed experiment. The conference gave cordial approval to the plan. It also expressed an unanimous opinion that in the experimental stages of working out a program it was essential to concentrate upon the most vital subjects of the fourth, fifth, and sixth grades and those of the junior high school.

The general features of the proposed experiment were included in the report of the Committee on Visual Education of the National Education Association at its annual meeting in June, 1926, and the general assembly of that body by unanimous vote expressed the opinion that an experiment of this character would render invaluable service to the educational interests of the nation and recommended that teachers and school officers throughout the country extend every possible assistance and coöperation in this experiment.

The experiment described in this paper, therefore, is the one now being conducted by the Eastman Kodak Company in coöperation with the schools of several cities of the country in the development and use of classroom films. The work of organizing the material and the planning of the experiment began in September, 1926.

There were certain lines of procedure in relation to motion pictures and to school room practice which had to be cleared up before the real work of this experiment was undertaken. For instance, in dealing with subjects intended to develop correct attitudes and habits in life on the part of children, as in courses relating to health, we have followed the procedure of basing films on the positive or constructive practices which show the benefits derived from pursuing such courses instead of basing the films on the negative or improper practices and the penalties resulting therefrom. There are also certain scenes entirely proper from the ethical viewpoint which would shock or intimidate children of sensitive nervous systems. Therefore, all scenes which might produce undesirable mental reactions on the part of children have been avoided in preparing Eastman classroom films; as, for instance, a scene in the film on Cattle which shows the branding process, scenes containing repulsive practices, etc.

Motion pictures have been so universally used since their beginning as a means of entertainment that in the great majority of attempts to adapt them to the use of the schools the entertainment idea has been carried over in them. The story and the drama are factors of great power in educational processes and especially with children of the lower grades. Where this form of instruction is

resorted to, it should be presented by the masters in story telling and in the dramatic field. But all the work of the schools should not be administered upon entertainment or dramatic lines. Films should not be made primarily to entertain children or to exert a dramatic power over them. They should be made with the intent to present accurate viewpoints and pictures of actual conditions representative of our social and economic life. The dominant tone and spirit of the film should be to present ideas, to reveal processes, to clarify situations, to represent actualities—to instruct.

Motion pictures should be what the term implies, and that is pictures which represent motion or action. These pictures should deal with situations, activities, operations, processes, etc. With these restrictions in their use there is an inexhaustible field of service for the motion picture. The subjects selected for filming should fall within these limitations. Certain subjects may be represented as well and even better by still pictures than by motion pictures. A program of motion pictures should not invade the still picture field. In the activities and processes of every avenue of human effort and interest are subjects of vital relation to society which can be represented accurately by the motion picture only. In developing films to be used in the Eastman experiment the limitations herein prescribed for motion pictures have been respected.

This experiment is designated as only one in the development of classroom films. What are classroom films and how do they differ from other films? The name itself denotes a special and definite use, and therefore a distinct type of film. The name implies a film used in the classroom by a teacher giving instruction to his pupils. This type of film is therefore simply a classroom agency in the hands of a teacher. It is to be used by him when needed, in the same way as other classroom aids or apparatus; it is not a substitute for the teacher nor for the textbook. It is just a tool to clarify his work and make it more impressive. It should be adapted to specific lessons and to definite grades.

The classroom film should be distinguished from the general assembly or auditorium film. The auditorium film is one intended for a general audience of varying ages, grades, and interests. It is used to provide entertainment or to give mass instruction. There is no competition between these two types of film. One does not serve the legitimate functions of the other. A film which is developed on pedagogical lines to illustrate a fundamental principle or to clinch

some central truth which the teacher is endeavoring to develop in the minds, for instance, of a class of sixth grade pupils is seldom adapted to the use of the general assembly. On the other hand, a film which will provide instruction or entertainment for the auditorium is not generally adapted to the more limited and specific purposes of the classroom.

Briefly, the plan of the experiment is as follows:

The school authorities in twelve cities of the country were invited to cooperate in the experiment. To give the experiment the benefit of varied interests and viewpoints in education and to make it expressive of national interests and conditions, cities were selected from various sections of the country. The following cities were chosen:

- | | |
|---------------------|--------------------------|
| 1. Newton, Mass. | 7. Oakland, Calif. |
| 2. Rochester, N. Y. | 8. San Diego, Calif. |
| 3. Detroit, Mich. | 9. Kansas City, Neb. |
| 4. Chicago, Ill. | 10. Atlanta, Ga. |
| 5. Lincoln, Neb. | 11. Winston-Salem, N. C. |
| 6. Denver, Colo. | 12. New York, N. Y. |

Four schools have been designated in each city for experimental work. Three of these are elementary schools and one is a junior high school. Two groups of children will be under instruction: the control group or those given instruction without the use of films, and the experimental group or those given instruction with the use of films. Each of these groups will represent children coming from similar home environments and social conditions in life. They will be given tests to determine that they are on the same intellectual level. In each city there will be at least 320 pupils receiving instruction in the same area of the subjects included in the experiment. There will be 160 receiving instruction with the use of the films and 160 without the films.

In six of the cities it has been planned to use 500 pupils in classes instructed with the use of films and 500 in classes without the use of films. In each of these six centers 1,000 pupils will be included in the experiment. It is believed that an experiment of this character with approximately 8,000 pupils in twelve leading cities in various parts of the country will be adequate to obtain reliable and convincing evidence on the problems involved in this experiment.

Three subjects in the school curriculum have been chosen, and films are being produced on topics outlined in the curriculum for

classroom consideration. These subjects are geography, general science, and health. In geography thirty films will be produced. They will be limited to the United States and will of course be correlated to the subjects as treated in the curriculum. They will be adapted to children of the fifth and sixth grades. In general science, fifteen films, and in health, five films are being produced. These films will be adapted to the pupils of the first and second year of the junior high school and will be correlated with the selected subjects treated in the curriculum.

It has already been stated that the scenes in motion pictures should denote action and that the films in this experiment are of such type. The following names of some of the geography films are given as evidence on this point:

Panama Canal, Bituminous Coal, Anthracite Coal, Iron Ore to Pig Iron, Pig Iron to Steel, Deep Sea Fishing, Wood Pulp, Wheat, Flour to Bread, Corn, Cattle, Wisconsin Dairies, Hydro-Electric Power in the Appalachians, The Overland Route, The Oregon Trail, and The Mohawk Valley.

In general Science these are some of the films:

The Water Cycle, Water Power, A Municipal Water Supply, and Purifying City Water.

This group of films on water affords sequences upon a common subject which is a necessity of life. There is no agency through which the interrelated interests and processes of these subjects could be presented so accurately and effectively to a class of pupils as through the motion picture. One of the problems of the classroom is to coördinate subjects in the curriculum in such a way that pupils may get a broader knowledge of these interrelations. For instance, "A Municipal Water Supply" is primarily a general science film. It has direct relation, however, to the subject of health and is a fine example of a film in the field of civics. Through no agency, either still picture or text, could this correlation of interests be so explicitly shown as through the motion picture. Appended to this paper is a complete list of the films in each subject which are being developed in this experiment.

We now come to the technical aspects of the development of a film program. The first step is, of course, the preparation of a scenario. A scenario for a classroom film should be correlated with the curriculum. It should deal specifically with the subject matter presented

through printed text and oral instruction in the classroom, which subject is intended to illuminate and clarify. It should call for material which will be within the intellectual grasp of children of the age and grade for whose instruction it is intended. It should deal strictly with its main thesis and should seldom go into digressions or upon excursions into other aspects of the subject. These collateral aspects should be treated in scenarios pertaining to their peculiar interests. It is not possible nor is it necessary to present in a film all the material bearing upon the subject to which it is related. It should never be padded. The basic features only, essential to a fundamental knowledge of the subject, should be presented.

The scenes called for in the scenario should be limited, of course, to subjects, situations, and processes which it is proper and suitable to present to a class of children. The scenario should be based upon sound principles of the psychology of childhood which scientific research has made available. The approach to a subject and its development in the scenario should conform to the practices of the classroom which are generally accepted in the teaching profession. The scenario should call for a film which should always be regarded simply as an aid to the teacher in his regular daily classroom instruction.

The continuity of a scenario should be clear and without a break. The wide gaps which may be allowable in a film for mature minds are not permissible in a classroom film for the instruction of children. The continuity may sometimes be strengthened through the judicious use of titles. On the other hand, too many titles often interrupt the continuity of thought. They should not be used when the continuity may be expressed and the scenes properly interpreted without them. Titles should be short, clear, and expressive. Not more than a single idea should generally be used in each one. This policy of using titles should be in keeping with the sound teaching principle that a child should not be told that which he may be able to see or discover for himself. Furthermore, there is an economic aspect to this feature of a film: Titles run rapidly into footage, and the more titles are used the less footage will of course be available for scenes.

It follows from these specifications that the writer of a scenario should be a teacher of broad and deep knowledge in the field which it covers. He should be experienced in the science of education and the art of teaching. He should be a scholar and teacher of creative power. He should be endowed with imagination and the genius of an

artist. He should be a master in the organization of material and should be skillful in presenting it in logical order and by effective methods.

The Eastman Kodak Company in the selection of scenario writers chose teachers who are known to be interested in the field of visual education and who have had large experience in teaching the subjects on which films are to be prepared. For instance, teachers of university training who had taught geography in public schools for 10 to 20 years and are recognized by their profession as leading teachers in that subject were chosen to aid in the preparation of the geography scenarios. Two of these are teachers in large city school systems and one is a teacher of geography in the training department of a State Normal School.

This group of experienced teachers sat in conference with the staff of the Eastman Kodak Company for several days discussing the place and purpose of the film and the underlying principles of scenario construction. Each member of the group then prepared a general outline of a film. Each of these outlines was considered by the staff and these teachers, in conference. After such conference each teacher revised his scenario, and the revised product was the subject of another general conference. These processes were repeated until the Eastman staff and the scenario writers were in unanimous agreement on the scenarios. These scenarios have generally passed through seven to ten revisions.

The scenarios were then edited by the Editor-in-Chief of the Eastman Staff. They were then submitted for criticism to two of the leading psychologists and specialists in education in this country—Dr. Frank N. Freeman, of the University of Chicago, and Dr. Ben D. Wood, of Columbia University. These men have the esteem and confidence of the educational workers of the nation. Each of them suggested modifications which in his judgment would remedy defects discovered or would otherwise improve the scenario. The scenario was given final editorial approval and was ready then for the photographic division. The same detail of procedure has been followed in preparing the general science and the health films.

In obtaining some of the scenarios for this experiment we followed a plan which has been of much interest. We suggested to the superintendant of each city in which the experiments are to be operated that the teachers would have a greater appreciation of the value of the film in classroom instruction and a clearer under-

standing of its application to the subject to which it relates if they were to write a scenario for one of the selected topics. The teachers in each of ten cities prepared a scenario under direction of the Editor-in-Chief of the Eastman Kodak Company. In several of the cities some of these teachers showed unusual ability in writing scenarios. They expressed themselves as being delighted with their experience and were eager to try a hand in writing another scenario.

When motion pictures have become such an established agency in classroom instruction as to receive popular recognition in the teaching institutions of the country, there will be such demand for scenarios that it will be an inducement to those teachers who are endowed with the intellectual qualities which prepare them for scenario writing to devote their talents to that phase of education service. When classroom films attain that status, scenarios will be brought to the producers of films on a plan somewhat similar to that which obtains between the authors and the publishers of text books. The author prepares his manuscripts and submits them to the publisher who either accepts or rejects them. The publishers of text books have the privilege of selecting the product of the leading teachers and text writers of the country. Similar privileges will come to the producers of classroom films.

The scenario is the photographer's chart. It should contain definite directions as to where scenes will be found and complete instruction as to the type of shots he is to take. A scenario should not call for a scene unless the author knows it is in existence and specifies where it may be found. The author of the scenario should be familiar with all scenes, operations, activities, or processes for which his scenario calls. They should be described with such detail and minuteness that a photographer will be able to interpret them. If necessary the author should even travel over territory which comes within the purview of his scenario to locate scenes which will produce the pictures contemplated.

This is not only sound practice from the viewpoint of accurate presentation of most appropriate scenes but it is also the economical procedure to follow. If a scenario contains definite descriptions of scenes and states where they may be found, a photographer will have no excuse for not obtaining them. Some one must take the time to locate the scenes called for in a scenario. The best judge of the scenes required is the author. He is the only person who knows exactly what he visioned in writing a description of the scenes. If

the photographic crew is required to locate all scenes, the film will express the judgment of the photographer as he has interpreted the scenario and may not represent the ideas which the writer of the scenario intended the film should convey.

This is no criticism of a photographer. An architect may design a building of rare lines and beauty. Another architect may take the designs and plans and in his interpretation of them make an utter failure in constructing the building contemplated by the designer. When a photographer works without these definite plans he often makes many photographs of the same scene, and he takes numerous scenes not called for in order to give the writer the privilege of selecting those which he regards most appropriate. It is not at all uncommon for a photographer to bring in 8 to 15 reels of negative to get one reel of the film. This practice is expensive and results in great waste. There is loss in the time of the photographic crew in locating the scenes and in taking unnecessary pictures; there is extravagant use of film in photographing a vast amount of unnecessary material; and there is additional waste in cutting or editing the reels to reduce the footage to the required amount. This practice adds much to the original cost of films. The cost of films is the outstanding obstacle at present to their more general use.

One of our experiments is a good illustration of this point. We prepared a scenario on Municipal Water Supply, taking the New York City supply as an example. A photographer went into the field and brought back four thousand feet of pictures. He reported he was unable to get many of the scenes called for in the scenario. Very little of the material he brought in was usable. The author of the scenario then went to the Gilboa Dam and traced the water from the source of supply on through to New York City. He spent one week in the field. He located every scene which was necessary to make his film. After returning to the office he revised his scenario. In the revised scenario he specified the exact location of each scene, the time of day in which it was to be photographed to produce the desired proper pictorial effect, and the direction in which the scene was to be shot.

The opinion prevails very generally that it is entirely feasible to select scenes for films adapted to school room needs from theatrical films, industrial films, and educational films which have been used for general entertainment purposes or mass instruction. There are of course many scenes in large numbers of these films which may be

used to advantage in preparing films adapted to classroom instruction. We have found it wholly impractical, however, to rely upon these sources for scenes for the Eastman classroom films. It usually involves as much labor and expense and takes as much time to obtain scenes for a classroom film from extant material as would be involved in sending photographers into the field to take original pictures. When films are assembled from these sources they are usually unsatisfactory. Enough scenes will be lacking so that the film fails to express the vision and the continuity of thought which the scenario represented.

The Eastman experiment has revealed not only the desirability but the very necessity of sending photographers into the fields and plants to get fresh pictures which will represent the life, spirit, and action expressed through the scenario.

There is another feature of motion picture service which illustrates how hide-bound we are to tradition. The motion picture programs in the schools usually include full reels. The great majority of schools set aside an hour and show three reels. Nearly all reels cover a period of fifteen minutes. The majority of the reels in our experiment are fifteen minute reels. Conditions in the educational world are such that it was necessary to make them of this length for the experiment. We are, however, departing somewhat from this tradition and are making several short reels. These reels are intended to illustrate one point in a lesson. It may take one minute or three minutes to present the essential points of a lesson in a film. The time to show such film is when the lesson is under consideration. For instance, a lesson in geography dealing with the cocoanut industry of the Philippine Islands is given to-day. At the appropriate time during the recitation the teacher will show a three minute reel dealing with that product. The next lesson may deal with the sugar industry and the one following, with the hemp industry. As these lessons are considered in recitation, the proper film will be shown.

As far as possible we have planned our films on a unit basis which will readily adapt them to this type of service. I have no hesitancy in prophesying that film programs in the schools will be developed eventually on this plan. Short films may be used for several subjects in the same school. This plan would provide economical service and be of great aid in extending film service in the classroom.

In photographic field work we have found that usually the best results have been secured by sending a director and cameraman to

photograph the scenes which the scenario calls for. The director has generally been a man who has worked very closely with our editorial staff. He has acquired a definite viewpoint of the scenario as a whole and understands its spirit and purpose. In his study of the scenario he has had to visualize the entire scenario and to work out each scene step by step so that it will fit into the general pattern.

In the field, the director specifies the outstanding features and determines the direction, distance, and even the composition of each scene, so that it will correlate with the scenes which precede and follow. He uses his initiative in taking advantage of situations as they occur on the ground. The sending of both director and cameraman adds unduly to the expense. Our experience justifies us in expressing the belief that we shall be able to train our photographers to do their own directing. For this purpose we are generally training selected men.

The motion picture is a new medium for classroom instruction and its use involves a careful study of educational values and of teaching practices. At present impressions gained through words bulk large in the usual classroom procedure, and the attention of teacher and pupil is devoted largely to searching out the ideas back of the words used. With motion pictures the center of interest tends to be reversed, and one of the outstanding problems is to find words with which to report clearly the observations made and the inferences drawn from direct visual experiences.

The lack of experience in the use of motion pictures on the part of teachers indicates that they should be supplied with carefully prepared directions and suggestions to aid them in the use of this unfamiliar tool in classroom instruction. This need for guidance is especially marked in the conduct of the Eastman experiment in order to secure treatment in widely separated classes that will afford comparable results.

It is doubtful if anyone is able at this time to anticipate and formulate the most effective technique for the use of motion pictures in the regular program of classroom instruction. Experience alone can indicate the best procedure to follow. One point, however, seems to stand out clearly. A line of distinction should be maintained between the things actually seen in the picture and the inferences drawn from them. In a law case witnesses are required to confine their testimony strictly to the observed facts, it being reserved to the judge and jury to draw inferences from the evidence rendered and to

pass judgment upon it. The situation is somewhat analagous in the use of motion pictures for instruction purposes except that the pupil plays the role of witness, judge, and jury. In the interest of clear thinking and sound conclusions, it is incumbent upon the teacher to see to it that these functions performed by the pupils are kept distinctly separate.

It has been pointed out that a specialized technique is required for the adequate presentation of motion pictures in classroom instruction. It is not enough simply to show a picture. What the teacher does with it after showing it is vital to good instruction. This specialized technique can be mastered by the teacher, through adequate training and experience.

With these considerations in mind, the Eastman Kodak Company has decided to prepare guides to go with each film and to hold conferences with teachers conducting the experimental classes in the various cities.

A plan to test the value of films for instructional purposes is being worked out. The Eastman Kodak Company will not formulate or conduct these tests. They will be organized and conducted under the direction of Dr. Freeman of Chicago University and Dr. Wood of Columbia University. These tests will be given to each group—the experimental group which receives instruction through the use of the film and the control group which does not have the use of the film in its instruction. Each group as far as possible must be under the instruction of teachers of equal ability, and each group must cover identical areas of instruction. The tests and measurements applied will be so constructed as to reveal the quantity, quality, and speed of achievement. An initial test will be given before the film instruction starts, and a final test will be given after the completion of all film instruction. Such intermediate tests as the specialists in charge of the work deem necessary will be made. These tests will comport to methods and standards which are recognized in educational circles as modern and sound. A preliminary announcement of the results of these tests will be made near the close of the current school year. A full, detailed report will be given the public in September, 1928.

The past year has been devoted to the preparation of scenarios and the development of films. No films have yet been used in the schools in the experimental centers. The first distribution of films will be made next month and monthly distribution will follow until

all films are supplied. At the end of the current school year we shall have evidence to determine the teaching value of classroom films. We cannot, therefore, speak to-day on this particular question involved in the experiment.

We can, however, speak upon some of the practical and economic aspects of the problem. There are several projecting machines which are easily operated and which may be purchased at reasonable prices. These are gradually being improved and simplified. A teacher may be trained to use them in a very short space of time. Even pupils in the school may easily learn to operate them.

The use of the 16mm. stock will make a substantial reduction in the cost of films. The use of this stock clears up another problem that has been troublesome. The 16mm. films are made on safety stock. The fire hazard to the schools is not only removed but the cost of installing booths is avoided. The circulation of films on a rental basis is not feasible nor does this method of supplying films serve the best interests of education. The school should own its own films. The cost of the equipment required for the use of classroom films and the cost of the films are within the financial ability of schools to provide.

I shall make a single prophecy that the film is to become an effective agency in teaching institutions of the country, that film libraries adapted to instructional purposes and coördinated with courses of study will in time be established in each school, college, and university, so that films adequate in number and character may be available for daily use of the teacher as maps, charts, textbooks, reference books, and scientific apparatus are now available for the purposes which they serve in the classroom.

List of Film Subjects

General Science

1. The Water Cycle
2. Water Power
3. A Municipal Water Supply
4. Purifying City Water
5. The Formation of Soil
6. Limestone and Marble
7. Sand and Clay
8. Compressed Air
9. Atmospheric Pressure
10. The Planting and Care of Trees

11. Reforestation
12. Fire
13. Heating and Ventilating
14. Fire Prevention
15. The Green Plant

Geography

1. The Hawaiian Islands
2. The Philippine Islands
3. The Panama Canal
4. Alaska
5. Bituminous Coal
6. Anthracite Coal
7. Iron Ore to Pig Iron
8. Pig Iron to Finished Product
9. The Automobile
10. The Mohawk Valley
11. New England's Deep Sea Fishing
12. Wood Pulp
13. Wheat
14. Corn Growing
15. Cattle
16. Wisconsin Dairies
17. Cotton Growing
18. The Old South
19. New Orleans
20. Hydro-Electric Power in the Southern Appalachians
21. Irrigation
22. The Pueblo Dwellers
23. The Painted Desert
24. The New South
25. Flour and Bread
26. The Union Pacific Pass
27. The Oregon Trail
28. Safety on the Sea
29. The Gateway of the Nation—Three Reels (New York City)

Health

1. Posture
2. Safety
3. Respiration
4. Circulation
5. Milk

DISCUSSION

MR. TAYLOR: Will the teacher in general be able to indicate the general points in the scenes, and will there be time for explanation during projection of the film?

DR. FINEGAN: That is contemplated, and the teacher's guide will give such suggestions as are deemed advisable on this point.

MR. RICHARDSON: I believe that Mr. Greene of Minneapolis has had considerable experience in the use of films in universities and I should like to hear his impressions.

MR. GREENE: The work with which I was connected was somewhat different from that which Dr. Finegan contemplates. We seldom dealt with audiences of less than four hundred, and our greatest problems were to so arrange seating, screen, projection equipment, and general illumination, often in rooms totally unsuited for projection, as to give good vision to all seats, to provide sufficient general illumination to permit the taking of notes, and still maintain a high degree of contrast in the screen image.

On the other hand, Dr. Finegan intends to project for very small audiences composed of students who probably are incapable of taking notes effectively. A lower level of general illumination and therefore a lower screen brilliancy will suffice in his case, and moreover the audience can in most cases be grouped so as to make effective use of a specular type of screen.

Now, what I am going to say is based on observation of mature students and may, therefore, be subject to some modification in the case of those who will form the audiences in Dr. Finegan's experiment. In the cases I have noted, however, the showing of motion pictures comes as a period of relaxation in a normally busy day, and the student, whether he knows it or not is ready to go to sleep when he settles himself in his seat. Then if on top of that you add the slightest eye strain, he at least loses his alertness and in many cases goes to sleep. It is scarcely too much to say that in educational work the projectionist must shoulder a part of the burden carried by the story in the theatrical picture and help to maintain interest through the realism of the illusion created. I believe the most serious menace to the success of Dr. Finegan's experiment which he must ceaselessly guard against will be the tendency of the teachers to try to extend the use of the present 16mm. projectors into fields where their beam power is hopelessly inadequate. Only the very highest quality of projection will be of any use whatsoever.

MR. RICHARDSON: The speed of projection is of importance too, because students must have time to absorb the ideas and to take notes.

MR. GREENE: It was our practice to slow down on a title almost to the flicker point and hold it until everybody had sufficient time to get it and then run at camera speed, this being maintained on action shots.

DR. FINEGAN: I didn't want to take the time of the meeting to go into all the details of this experiment. It would require four or five papers. I did try to point out that these films are for class room, not for auditorium use, for rooms with 35 or 40 pupils. The Kodak Company is supplying each school with all the apparatus and paraphernalia to carry the program through, and when the machines are set up, the technical men from the office will instruct the teachers in the use of the machinery and the conditions which should prevail.

MR. MCGUIRE: Is printed matter available on the progress in this field? Is a list of interested individuals being made?

DR. FINEGAN: As soon as there is information to be given to the public it will be given to anybody wanting it. Announcement will be made through the press or other channels which seem desirable.

MR. BRIEFER: Without a doubt, motion pictures will take a very important place in the educational field. All the questions pro and con as to the manner in which they might be shown could be protracted to great lengths, but probably through experience the manner of showing them and the explanation of the work to the pupils will be adjusted. My impression is that previous to the showing of the pictures, a skeleton outline of what is to be expected should be given to the pupils and the details left to their imagination. It is improbable that pupils could take notes while the picture is going on except when slow motion is being shown.

MR. BAUER: In one portion of the paper read, it was stated that two classes were to be formed, one of 400 children to be educated with the aid of motion pictures and one of 400 to be educated without motion pictures, both on the same subject. There might be some reflex action of a psychological nature in that the children from the same school without the aid of motion pictures might have some infant jealousy that would handicap them. They might feel that "Johnny Jones" in the other class is getting something better because he is getting the movies.

DR. FINEGAN: This is already being done throughout the country without any embarrassment.

MR. BAUER: The test might be more fair if the classes selected were more remotely connected.

DR. FINEGAN: I am afraid that those experienced in such tests would not think that was a comparable test. Children should be taken in the same city having the same background, but undoubtedly there is something to what you suggest. The film will be a little to the disadvantage; the children who are not receiving instruction under the film will profit by it being carried over to them.

MR. BAUER: This is just a phase on which I wanted enlightenment.

MR. COFFMAN: I happen to have been in a rather fortunate position to observe this experiment closely, and I believe that already much has been accomplished, whatever may be the final result. The educational world has always been conservative, probably because students who like the methods by which they were instructed tend to become educators, while the more radical tend to break away from the teaching world. The great problem in visual education has been the penetration of this ultra-conservative atmosphere surrounding the average school official. Previous efforts have been made by class room teachers not yet completely immersed in conservation, with the feeling that here is a tool of which efficient use can be made. They have met with general apathy on the part of their superiors. The Kodak Company with the aid of Dr. Finegan has been able to get the attention of prominent educational officials everywhere, and they in turn have been suddenly demanding that class room teachers give similar attention to this problem. You may be sure that the project will be followed attentively by the entire educational world.

Probably some of you have shared in previous teaching film experiments and know how difficult it is to get appropriations for the work which you feel is intensely important. Because of the magnitude of the Eastman Company's Experiment, and because boards of education have come to know its importance, I believe it has already justified its undertaking and the money spent upon it.

MR. MCGUIRE: Have you any impression as to whether the class room use of films will increase or decrease auditorium use.

DR. FINEGAN: I think it will decidedly increase auditorium use. When film programs get momentum and school authorities formulate general programs for visual education, it is inconceivable that the auditorium film will be omitted. It will be related, of course, to the school activities, community interests, and matters of general information.

MR. CUFFE: The same thing is being carried on all through Europe, particularly England, with great success—both class room and auditorium work— and it is thoroughly successful over there.

DR. ROSENBERGER: The same is true for Germany.

DR. FINEGAN: I have a letter from a school superintendent in Scandinavia in which he states that a committee is withholding a report on motion pictures in their schools until the results of this experiment are declared.

THE PHOTOGRAPHIC REFLECTING POWER OF COLORED OBJECTS

LOYD A. JONES*

IN A previous communication¹ the use of panchromatic negative film for motion picture work was discussed at some length, and the many advantages arising from the use of this material in the reproduction of scenes consisting of collections of variously colored objects was emphasized. In a later communication² the subject of characteristics of light filters and methods of using them to obtain any desired rendering of colored objects was treated. In these papers attention was directed chiefly to the exposition of fundamental laws and theoretical relationships which determined the quality of tone reproduction obtained when a series of colored objects is rendered by a photographic process as a series of brightness values entirely lacking in differentiated hue and saturation factors. Reasoning from these established relationships, certain qualitative conclusions relative to the photographic rendition of colored objects were drawn, but no data of a quantitative character relative to the subject were given. For instance, it is evident from a consideration of the spectral sensitivity of photographic materials and the spectral sensibility (visibility) of the eye that while a red object may have a very high visual brightness and hence be equivalent visually to a gray near the white end of gray scale, this same red object when rendered by means of orthochromatic film will have a low photographic brightness and hence will be rendered in the photographic reproduction near the black end of the tonal scale. Likewise, from a consideration of the spectral sensitivity of panchromatic film, it is apparent that this same red object when rendered by means of panchromatic film should have a much higher photographic brightness and therefore lie nearer to the white end of the gray scale and hence be rendered more nearly as it is seen visually. From the data already given relative to the spectral sensitivity of photographic materials, quality of light, and reflection characteristics of colored objects, it is possible to draw many such qualitative conclusions.

* Communication No. 327 from the Kodak Research Laboratories.

¹ "Panchromatic Negative Film for Motion Pictures" by Loyd A. Jones and J. I. Crabtree, *Trans. S.M.P.E.*, No. 27, 131 (1926).

² "Light Filters, Their Characteristics and Applications in Photography" by Loyd A. Jones, *Trans. S.M.P.E.*, No. 30, 135 (1927).

In this paper it is proposed to give some definite quantitative data relative to the reflection characteristics of certain well defined colored objects as measured in terms of certain photographic materials differing in spectral sensitivity.

Theoretical

A reflection factor in the broadest sense is defined as the ratio of reflected to incident radiant flux. This is strictly true in any case where a single wave-length of radiation is concerned and is applicable when it is desired to express reflection factor in terms of radiation. In

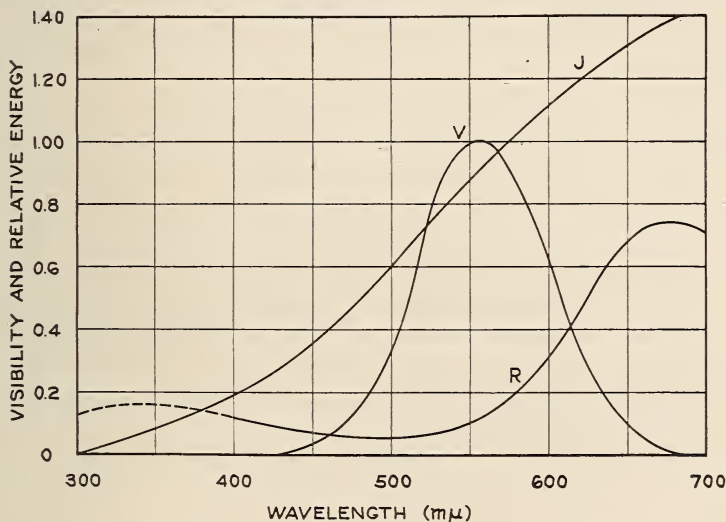


FIG. 1. Spectrophotometric functions involved in the evaluation of visual reflection factor.

tone reproduction work, however, we are concerned with the visual evaluation of radiant energy, and hence in defining the reflecting power of the colored object it is necessary to consider the way in which the eye responds to radiation of different wave-lengths. It is obvious therefore that the visibility function must be considered. The brightness of an object as seen by the eye depends upon the quality of radiation which is incident thereon and the selective absorption of that object. For our purposes therefore we must define reflection factor as the ratio of the *reflected* luminous flux to the *incident* luminous flux. The fundamental relationships which are concerned in the determination of visual reflection factor are shown in Fig. 1.

Curve V represents the sensibility of the eye to radiation of different wave-lengths. This is commonly referred to as the *visibility* curve and is plotted with its maximum ordinate equal to unity.

Curve J shows the spectral distribution of energy in the radiation from an assumed light source which in this case is incandescent tungsten operating at a color temperature of 3200° K. The ordinates of this curve are merely relative and show the relative amount of radiation at various wave-lengths between 300 and 700 $m\mu$.

Curve R is the spectrophotometric reflection curve of an assumed colored object. The curve shown applies to a panel painted with the pigment known as Vermillion. The ordinates of this curve are directly proportional to the amount of energy reflected at the various wave-lengths.

Now, the visual evaluation of radiation is shown by a curve obtained by multiplying the ordinates of curve J by those of curve V wave-length by wave-length. This curve is known as the *luminosity* curve of the source, and the area which it encloses may be taken as directly proportional to the brightness factor of the radiation. After reflection from the object represented by curve R the visual evaluation of the reflected radiation is given by multiplying the luminosity curve by the spectrophotometric reflection curve, and the area enclosed by the curve thus obtained when compared with the area under the luminosity curve will give the reflection factor for the colored object. This may be expressed formally by

$$R_V = \frac{\int_0^{\infty} J_{\lambda} V_{\lambda} R_{\lambda} d\lambda}{\int_0^{\infty} J_{\lambda} V_{\lambda} d\lambda}$$

where J_{λ} , V_{λ} and R_{λ} represent values of various functions at wave-length λ . It is evident from this that the *visual reflection factor* R_V for any object is dependent upon three factors: the spectral distribution of radiation in the source of illumination, the visibility function of the eye, and the spectrophotometric reflection characteristic of the object in question.

Considering now the question of reflection factor as evaluated in terms of a photographic material, we may treat the case in an exactly analogous manner, merely substituting for the *visibility function* referred to above the curve which shows the *spectral distribution of sensitivity* for the photographic material in question. In

Fig. 2 the various relationships which must be considered in evaluating photographic reflecting power are shown. The J and R functions are the same as those already shown in Fig. 1. The curve designated as A is the *photibility* curve for an orthochromatic material, its ordinates being relative sensitivity of the material at the different wave-lengths indicated. One other factor which must be taken into account in this case is the spectral absorption of the lens used in the camera to form an image of the object on the sensitive material. Inspection of Fig. 2 reveals the necessity of including this factor. It will be noted that the photographic material has very great sensitivity

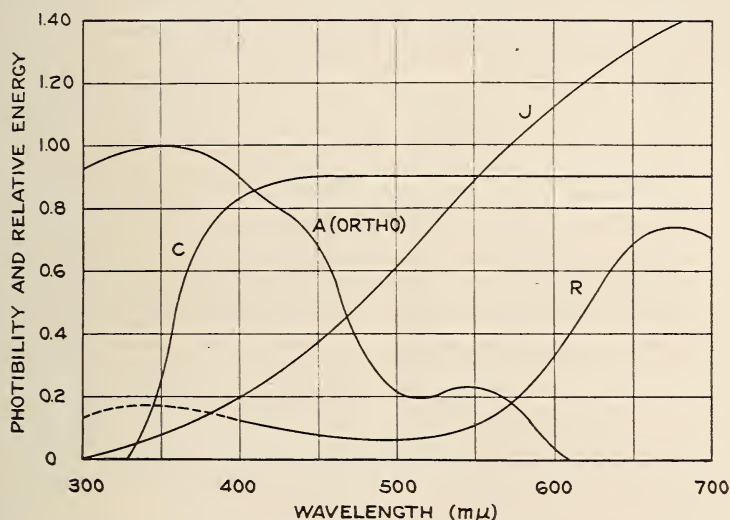


FIG. 2. Spectrophotometric functions involved in the evaluation of photographic reflection factor using orthochromatic negative film.

throughout the region lying between 300 and 400 $m\mu$, and colored objects may reflect to a certain extent radiation of these wave-lengths, although experience has shown that but few do reflect very freely in this region. Failure to take into account the absorption of the lens in this region may, however, lead to incorrect results.

The photographic evaluation of radiation, effective when pictures are being taken by means of a glass lens, is given by a curve obtained by multiplying together, wave-length by wave-length, the ordinates of curves J , A , and C . This curve is analogous to the *luminosity curve* ($energy \times visibility$) and is called the *photicity curve*

(*energy* \times *photibility*) of the light source represented by the *energy* (J) function used. Since the *photibility* function is different for various photographic materials, it follows that the *photicity* curve for a given light source is dependent upon the photographic material assumed in its computation. It is necessary therefore in speaking of a photicity curve to designate in some manner the photographic material in terms of which it is evaluated. This can be done conveniently by prefixing an abbreviation which indicates the photographic material. For instance, the photicity curve derived from the data shown in Fig. 2 may be called the *ortho-photicity* curve for tungsten illumination,

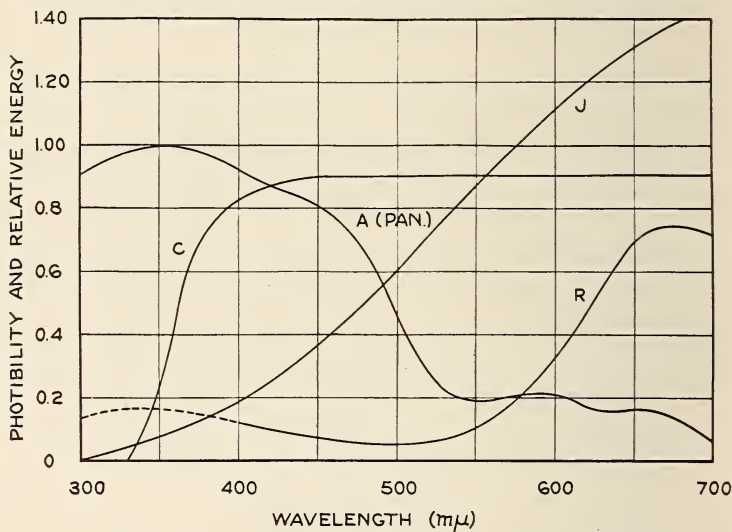


FIG. 3. Spectrophotometric functions involved in the evaluation of photographic reflection using panchromatic negative film.

while that derived from the functions shown in Fig. 3 may be termed the *pan-photicity* curve for tungsten illumination.

The photographic evaluation of the radiation reflected by an object of which k is the spectrophotometric reflection curve is given by a curve obtained by multiplying together the ordinates of curves J , A , C , and R . The relative areas included under the two curves thus obtained represents the photographic reflecting power of the object in question. Thus photographic reflecting power may be defined in terms of the fundamental characteristics by the equation

$$R_P = \frac{\int_0^\infty J_\lambda A_\lambda' C_\lambda R_\lambda d_\lambda}{\int_0^\infty J_\lambda A_\lambda C_\lambda d_\lambda}$$

It is evident from a consideration of these fundamental relations that photographic reflecting power depends fundamentally upon four factors: the spectral sensitivity of a photographic material, the distribution of energy in the radiation illuminating the object, the spectrophotometric reflection characteristic of the object, and, when the image is formed by means of a glass lens, upon the spectrophotometric transmission function of the lens. The curves shown in Fig. 2 are adequate for the determination of photographic reflecting power evaluated in terms of an orthochromatic material, such as the Par- and Super-Speed motion picture negative films.

It is evident that if panchromatic film is used, the *photibility* function will be different from that shown in Fig. 2, and in Fig. 3 curve *A* represents the *photibility* function for panchromatic material. A comparison of the shape of the *A* curve in Fig. 3 with that of the *A* curve in Fig. 2 shows very clearly why the reflecting factors of colored objects are different when measured on panchromatic materials from those obtained by use of orthochromatic materials.

The discussion in this section is given to establish a definite conception of the theoretical relationships involved in the evaluation of reflection factor in visual and photographic terms. In case the various characteristics illustrated by curves in Figs. 1, 2, and 3 are known with sufficient precision, values of reflection factor can be derived by direct computation of the *luminosity* and *photicity* curves and by a numerical integration of the areas enclosed thereby. In general, it is not possible to pursue this method on account of the lack of sufficient data. The curves *V*, *A*, *R*, and *C* are known with sufficient precision to permit their use in computations of this kind, and energy relationships for certain light sources are also known with satisfactory precision. For instance, the distribution of energy in the radiation from incandescent tungsten at any specified temperature is known and hence for this particular source determinations of reflection factor can be made as outlined. For many of the sources used in the motion picture studio, however, such as the flame arcs, the energy characteristic has not been determined with sufficient precision, nor is it probable that this can be accomplished without

excessive effort. Practically it is much easier to determine reflection factors by a more direct method.

Practical Methods

The usual method and one which is generally considered to be satisfactory for the determination of visual reflection factors in the case of colored objects involves the use of the flicker photometer. The literature of this subject is very voluminous and no attempt will be made at this time to present a review of the material. It will be sufficient to state that a direct visual comparison of the surface whose reflection factor is to be measured with a surface of known reflection factor is made. The photometric field used is one in which the unknown and the known are alternately presented to the eye, the frequency of alternation being adjusted to an optimum value, the criterion of equality being the absence of flicker in the photometric field. It is necessary to use such a method when comparing the *brightness* of differently colored objects in order to minimize the disturbing influence of hue and saturation differences on the judgment of brightness equality.

The photographic reflection factor of an object can be measured by the usual methods of photographic photometry. This also involves the direct comparison of the unknown with objects or surfaces having known reflection factors.

Surfaces which reflect to the same extent all wave-lengths of radiation to which the eye is sensitive are said to be *non-selective*, and such colors are designated by the general term *gray*. If this constancy of reflection factor extends also throughout the region to which the photographic material is sensitive, the surface is said to be photographically non-selective, and the reflection factor of such a surface measured visually is identical with the reflection factor of the surface measured photographically. By choosing a series of such surfaces varying in reflection factor from a low to a high value and making photographs of them along with the selectively reflecting surfaces of unknown reflection factor, it is possible to determine directly the photographic reflection factor of these unknowns. This is the method usually adopted for such work and does not require a determination of the fundamental relationships referred to in the previous section.

Color Panels

For this work a series of color panels was prepared using in so far as possible well known and reproducible materials. From the

lists published by Windsor & Newton Company a selection was made of a large number of pigments in oil designated as *very permanent*. This company has established a good reputation for uniformity of products and these materials can be easily obtained. Hence anyone vitally interested in this subject can prepare samples duplicating very precisely those used by us in this work. Pieces of Trootex artist's board 6×12 inches were obtained and given three coats of the pigment material. The pigment from the tube was thinned to brushing

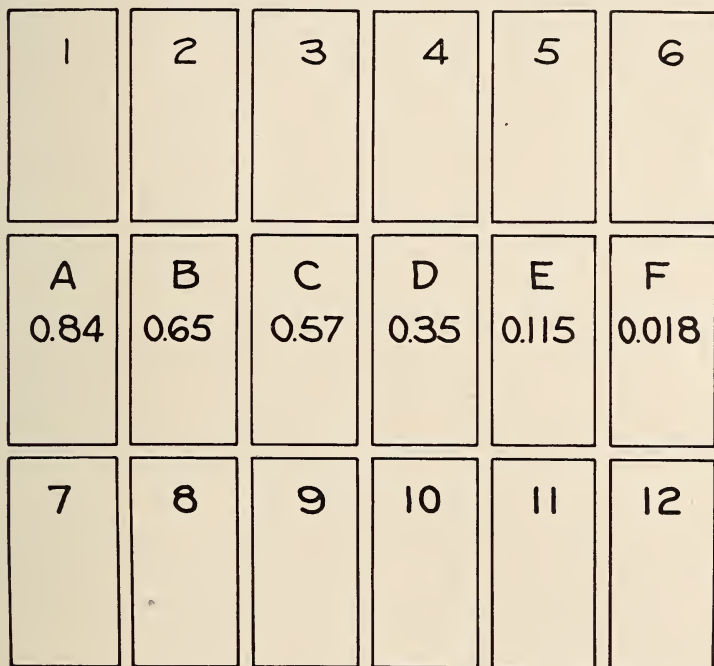


FIG. 4. Diagram showing the arrangement of test panels for direct measurement of photographic reflection factor.

consistency with turpentine, to which was added a few drops of clear Japan drier. In some cases of the very dark pigments having extremely low reflection factors, it was considered advisable to raise the brightness by dilution with white. For this purpose the Windsor & Newton No. 1 White was used and dilutions were made to definite percentages by weight. In the tabulated results a percentage value following the name of the color indicates the percentage of colored pigment in the mixture, the remainder being No. 1 White.

In order to facilitate the photography of these panels along with the gray panels of known reflection factor, a frame was made as illustrated by the diagram in Fig. 4. This was constructed very much like a window frame so that the panels could be put into position from behind and held in position by spring clamps. The center row lettered *A*, *B*, *C*, etc., was a series of gray panels which were made by exposing photographic developing-out paper to different extents and developing in a solution designed specifically to give a gray or non-selective deposit. The numbers as shown in Fig. 4 represent the reflection factors of the various panels. It was impossible to obtain, by using a matte photographic paper, a panel of as low reflection factor as was desired; hence for this panel *F* a piece of undertakers paper was used having a reflection factor of 0.018. These panels were examined very carefully for selectivity and approached closely to perfection in this respect. The reflection factors for these standard gray panels were determined with the flicker photometer which was used also to measure the visual reflection factors of the color panels. Readings were made by several observers and the average taken. The other openings in the frame, 1, 2, 3, . . . 12 (Fig. 4) were filled with the color panels to be measured. This was then mounted in a perpendicular position and the camera lined up with its optical axis perpendicular to and passing through the center of the frame holding the test panels. The test panel was then illuminated by light incident at approximately 45° , and in this way the specular component of reflected light, if such existed, was thrown out and did not enter the camera lens. The values measured therefore are those of diffuse reflection factor. Photographs of the color panels were made using Par-Speed cine negative film, Super-Speed cine negative film, and Panchromatic cine negative film. With all of these materials all of the panels were photographed with light of various qualities as given by the units commonly used in motion picture studio work.

Light Sources

Tungsten. The unit used for obtaining tungsten illumination was that described previously in a communication read before this society.³ The lamps were operated on the 10 per cent over-voltage, thus giving radiation of approximately 3200° K color temperature.

³ "Incandescent Tungsten Lamp Installation for Illuminating Color Motion Picture Studio" by Loyd A. Jones, Trans. S.M.P.E., No. 22, 25 (1925).

White flame carbon arc. The unit used was a Creco Broadside carrying 35 ampere twin arc trimmed with National Carbon Company white flame photographic carbons.

Orange flame carbon arc. The unit used was a Creco Broadside carrying 35 ampere twin arc trimmed with National Carbon Company orange flame carbons.

Plain carbon spot. The unit used in this case was a Winfield Kerner 85 ampere spot light trimmed with plain (low intensity) carbons. This unit is equipped with a plano convex condensing lens of approximately 8 inch diameter and 12 inch focal length.

High intensity carbon arc. The unit used was a 75 ampere G. E. automatic high intensity spot trimmed with the high intensity carbons. It was desired to obtain as nearly as possible radiation of the quality given by the G. E. sun arcs as used in the studios. The plano convex lens with which the 75 ampere spot is equipped was removed, and in front of the housing was placed a $\frac{1}{4}$ inch silver mirror obtained from the Bausch & Lomb Optical Company and resembling closely in quality of glass and reflecting surface the mirror material used in the manufacture of the parabolic reflector with which the G. E. sun arcs are usually equipped. The light after reflection from these mirrors illuminated the colored samples under test.

Mercury vapor arc. Two 50 inch Cooper Hewitt tubes of standard DC type were used, one mounted on each side of the test frame.

Experimental Procedure

The amount of illumination incident on the test panels was adjusted to a value such that an exposure time of 0.04 seconds gave a density of approximately 0.5 on the area representing the black panel, *F*. The exposure time chosen is of the same order as that predominantly used in motion picture work, and the density corresponding to the black object is sufficiently high to lie approximately at the lower end of the straight line portion of the density-log exposure curve of the photographic material.

The negatives were developed by the brush method, thus insuring a maximum of uniformity. The resulting densities were measured by means of a physical photometer employing a thermopile as the light sensitive element. The optical system of this instrument is such that the value read is that of specular density, the silver deposit being illuminated by a beam of collimated light. The negative image of each test panel was approximately $\frac{1}{2}$ inch wide by

1 inch long, and the densitometer was so arranged that this entire area was integrated, thus giving a density value which represents the average for the entire image. This procedure tends to eliminate errors which might be introduced by the presence of non-uniformity in the panel itself.

In Table 1 is given a typical set of data obtained from one of the negatives. In the first column are given the panel designations, and in the second column the color names. In the third column are the density values read from the negative. The values of R_P for the

TABLE 1

Typical set of data illustrating method of computing photographic reflection factor.

Film: Cine Negative Super-Speed (Ortho).

Light Source: Incandescent Tungsten (3200°K).

<i>Panel</i>	<i>Color</i>	<i>Density</i>	<i>Log R</i>	R_P	R_V
A	White	—	1.924	0.84	0.84
B	Gray	2.90	1.813	0.65	0.65
C	"	2.80	1.756	0.57	0.57
D	"	2.50	1.544	0.35	0.35
E	"	1.90	1.061	0.115	0.115
F	Black	0.80	2.255	0.018	0.018
49	Cadmium Yellow	1.68		0.074	0.53
51	Spectrum Yellow	1.62		0.068	0.49
52	Raw Sienna	1.42		0.050	0.14
53	Yellow Ochre	1.69		0.074	0.28
58	Cadmium Orange	1.51		0.057	0.38
59	Vermillion Orange	1.44		0.052	0.48
60J	Veridian, 50%	2.38		0.28	0.16
61	Cobalt Green	2.16		0.19	0.18
62	Cadmium Green	1.76		0.075	0.12
64	Cobalt Violet	2.38		0.27	0.12
65B	Spectrum Violet	2.18		0.20	0.082
66	Permanent Violet	2.81		0.11	0.062

panels A to F inclusive were determined, as stated before, by a visual method with the flicker photometer. The logarithms of these values determine the points along the log exposure axis (see Fig. 5) at which the negative densities corresponding to the various gray panels are plotted in order to establish the characteristic curve of the negative material on which the test was made. In Fig. 5, the method of plotting this characteristic curve is shown, the points B, C, D, E, and F being established from the data in Table 1. The ordinate values

of these points are derived from the density values read directly from the negative, while the abscissa values are obtained by taking the logarithms of the reflection factors as determined visually. It should be kept in mind that the validity of this method depends upon the assumption that the visual and photographic reflection factors of these gray panels are identical. It will be noted that the negative density corresponding to panel *F* is 0.80. It is known from experience that

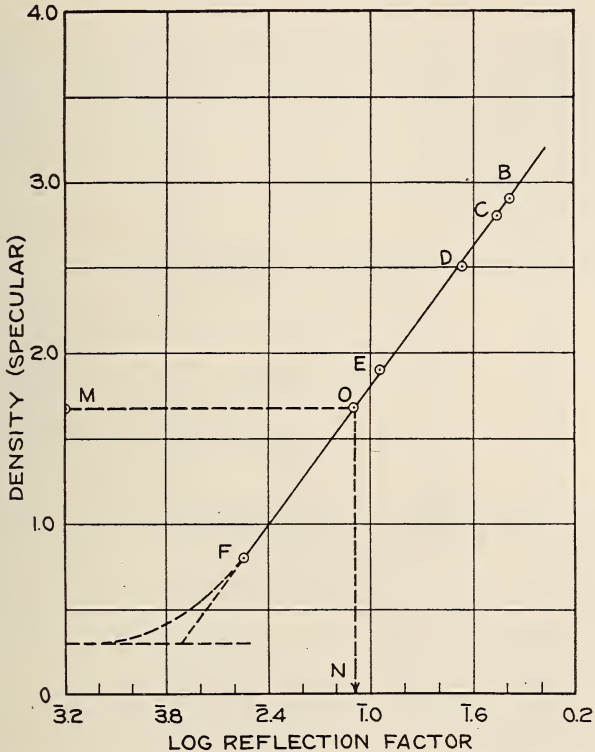


FIG. 5. Characteristic log exposure curve of photographic material illustrating method of deriving photographic reflection factor.

this density should lie on the straight line portion of the characteristic curve of the photographic material used (Super-Speed Cine Negative). The points *B*, *C*, *D*, *E*, and *F* it will be noted lie very closely on the same straight line. This straight line, therefore, becomes the density-log-reflection factor (or log exposure) characteristic of the material.*

* Log reflection factor and log exposure are interchangeable in this case because the time factor of exposure is constant for all of the panels.

The method of finding the reflection factor of one of the unknown color panels is illustrated by the points N , O , and M . The negative density for cadmium yellow, it will be noted from Table 1, is 1.68. This value is laid off on the density axis at point M . The horizontal line through this point establishes the point O on the characteristic curve and a perpendicular dropped from this point determines the point N on the log reflection factor scale. By finding the number of

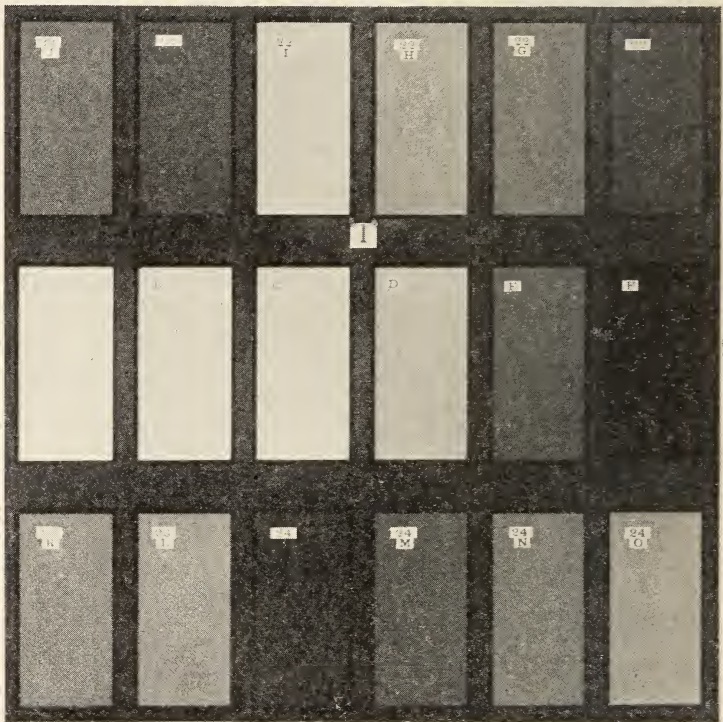


Fig. 6. Print from one of the negatives made in measuring photographic reflection factor of color panels.

which this is the logarithm the reflection factor of the cadmium yellow panel is obtained. In the column R_P are shown the reflection factors for the various color panels when illuminated by tungsten lamps and photographed on Super-Speed Cine Negative film. In the column R_V are shown the visual reflection factors of the various colors. In exactly the same manner the photographic reflection factors for

the entire group of color panels was determined under various illuminations and with different photographic materials.

Results

In Table 2 are given the reflection factors of 25 different color panels as measured with panchromatic film under different qualities of illumination. The values in the column R_V are those of *visual reflection factor* as determined by the flicker photometer method.

TABLE 2

Reflection Factors, Panchromatic Film

No.	Color	R_V	R_P (Panchromatic)					Hg.
			Tung.	O.F.	P.C.	W.F.	H.I.	
71	Spectrum Red	12.0	12.0	8.0	4.9	3.4	3.2	1.5
72	Vermillion	22.0	18.0	16.0	11.0	9.6	7.6	5.2
59	" Orange	48.0	24.0	17.0	16.0	13.0	11.0	7.1
58	Cadmium Orange	38.0	23.0	17.0	12.0	11.0	10.0	5.6
49	" Yellow	53.0	23.0	20.0	17.0	13.0	12.0	8.1
51	Spectrum Yellow	49.0	22.0	19.0	13.0	12.0	9.3	7.1
19	Chrome Yellow DO	30.0	23.0	20.0	14.0	13.0	8.9	6.5
18	" " Orange	44.0	30.0	27.0	20.0	17.0	11.0	8.5
16T	" " Lemon, 50	55.0	34.0	30.0	28.0	22.0	16.0	13.0
53	Yellow Ochre	28.0	16.0	14.0	12.0	9.6	10.0	7.1
107	Apple Green	43.0	26.0	20.0	17.0	16.0	14.0	12.0
109	Emerald Green	35.0	23.0	16.0	15.0	20.0	16.0	12.0
62	Cadmium Green	13.0	10.0	8.3	8.1	8.5	7.8	6.2
61	Cobalt Green	18.0	17.0	12.0	14.0	16.0	14.0	14.0
60J	Viridian, 50	16.0	22.0	17.0	26.0	20.0	23.0	24.0
80W	Cobalt Blue, 25	27.0	42.0	48.0	54.0	51.0	56.0	50.0
82E	Prussian Blue, 25	8.0	14.0	15.0	20.0	16.0	17.0	17.0
83G	French Ultramarine, 50	10.0	22.0	25.0	35.0	28.0	30.0	34.0
83	" "	4.0	5.0	5.6	5.4	6.2	6.5	6.2
30	Ultramarine Blue	4.9	13.0	14.0	18.0	17.0	17.0	19.0
64	Cobalt Violet	12.0	26.0	26.0	28.0	30.0	30.0	37.0
65B	Spectrum Violet, 12.5	8.2	14.0	14.0	20.0	18.0	18.0	21.0
66	Permanent Violet	6.2	9.0	8.5	8.0	10.0	12.0	14.0
95L	Purple Lake, 50	8.7	11.0	11.0	15.0	12.0	11.0	12.0
96	Magneta Lake	4.5	3.8	4.0	2.9	3.2	7.2	3.6
73A	Permanent Crimson, 50	9.5	9.8	9.0	8.7	7.1	8.7	11.0

It is obvious that for perfect orthochromatic reproduction the photographic reflection factor of a panel should be identical with that as shown under R_V . The reflection factors R_P panchromatic are given in the last six columns of the table. The abbreviations at the head of the columns designate the quality of light with which the panels

were illuminated. The significance of these abbreviations are as follows:

Tung.—radiation from incandescent tungsten at color temperature of approximately 3200°K.

O.F.—orange flame carbon, 35 ampere twin arc in Creco Broadside.

P.C.—plain carbon, 85 ampere arc in Winfield Kerner spot light unit.

W.F.—white flame carbon, 35 ampere twin arc in Creco Broadside.

H.I.—high intensity arc on the G.E. 75 ampere high intensity spot light unit.

Hg.—the Cooper Hewitt mercury vapor arc, 50 inch standard D.C. tubes.

The colors are arranged in the table approximately in the same order as the colors in the spectrum from red to violet. The light sources are arranged with tungsten the "yellowest" in the first column, and progressively to the right from this column the quality of illumination becomes "bluer." It will be noted that in case of the red, orange, and yellow colors the reflection factor decreases as the color of the illuminant becomes bluer. This of course is to be expected. This general gradient of decreasing reflection factor for increasing blueness of illuminant continues down into the green region and for Emerald Green, Cadmium Green, and Cobalt Green, the reflection factor is very nearly independent of the quality of the illuminating radiation. In the case of Veridian, which is a blue-green, the gradient is reversed and the reflection factor tends to increase with the increasing blueness of the illuminant. This continues in general into the blue region and is true for some of the violets. It should be remembered that the pigment color designated as violet is really a mixture of red and blue, not a pure spectral color. Hence the reflection factor for some of these pigment violets is practically independent of the color of the illuminant. This follows from the fact that they are reflecting both red and blue and hence on panchromatic film tend to balance fairly well. Purple Lake (No. 95L) is a mixture of red and blue in which the blue is still predominant, but in the case of Magenta Lake (No. 96) the red has become predominant and the reflection factor for this tends to behave in the same manner as the red pigment, although the gradient as the "blueness" of the illuminant increases is not as great as for a pure red. Permanent Crimson (No. 73A) is a color in which red is greatly predominant but it does reflect some blue or short-wave radiation. It therefore tends to behave more like a red than like a blue. It will be noted that on the average the reflection factors of these colors as measured with tungsten on film are more

nearly equal to the visual reflection factors than for any other light source. This demonstrates very clearly the advantage of using tungsten illumination with panchromatic film when it is desired to obtain approximate orthochromatic rendering of the colored objects.

TABLE 3

Comparison of photographic reflection factors obtained when using panchromatic and orthochromatic film under three different qualities of illumination. Tung.—incandescent tungsten at 3200°K. P.C.—plain carbon arc (color temperature approximately 4000°), H.I.—high intensity arc (color temperature approximately 5400°).

		Reflection Factors						
		Tung.			P.C.		H.I.	
No.	Name	R _v	Pan.	Ortho	Pan.	Ortho	Pan.	Ortho
71	Spectrum Red	12.0	12.0	1.8—	4.9	1.8—	3.2	1.8—
72	Vermillion	22.0	18.0	6.0	11.0	5.7	7.6	7.1
59	“ Orange	48.0	24.0	5.5	16.0	8.9	12.0	8.5
58	Cadmium Orange	38.0	23.0	5.7	12.0	7.0	10.0	8.1
49	“ Yellow	52.0	23.0	7.9	17.0	7.9	10.0	7.5
51	Spectrum Yellow	49.0	23.0	7.2	13.0	5.4	9.3	6.0
19	Chrome Yellow DO	30.0	23.0	8.1	13.0	6.8	8.9	7.7
18	“ “ Orange	44.0	30.0	10.0	20.0	9.6	11.0	9.8
16T	“ “ Lemon,							
	50	55.0	34.0	15.0	28.0	14.0	16.0	12.0
53	Yellow Ochre	28.0	16.0	7.8	12.0	9.8	10.0	12.0
107	Apple Green	43.0	26.0	14.0	16.0	10.0	14.0	11.0
109	Emerald Green	35.0	23.0	28.0	16.0	15.0	16.0	17.0
62	Cadmium Green	13.0	10.0	8.8	8.1	10.0	7.8	8.4
61	Cobalt Green	18.0	17.0	20.0	14.0	17.0	14.0	13.0
60J	Viridian, 50	16.0	22.0	28.0	26.0	33.0	23.0	22.0
80W	Cobalt Blue, 25	27.0	42.0	50.0	54.0	58.0	56.0	60.0
82E	Prussian Blue, 25	8.0	14.0	20.0	20.0	22.0	17.0	20.0
83G	French Ultramarine, 50	10.0	22.0	33.0	30.0	41.0	35.0	31.0
83	“ “	4.0	5.0	7.0	5.4	6.8	6.5	7.5
30	Ultramarine Blue	4.9	13.0	21.0	18.0	23.0	17.0	22.0
64	Cobalt Violet	12.0	26.0	28.0	26.0	33.0	28.0	32.0
65B	Spectrum Violet, 12.5	8.2	19.0	20.0	20.0	25.0	18.0	21.0
66	Permanent Violet	6.2	9.3	8.8	8.0	13.0	8.5	10.0
95L	Purple Lake, 50	8.7	11.0	13.0	14.0	16.0	11.0	15.0
96	Magenta Lake	4.5	3.8	2.6	2.9	2.6	4.2	3.2
73A	Permanent Crimson, 50	9.5	9.8	6.1	16.0	16.0	8.7	11.0

In Table 3 are given reflection factors for the same group of color panels as measured with orthochromatic motion picture film under three different illuminants, and for comparison along with these are given the values as determined by means of panchromatic film.

Measurements of reflection factor were made using both the Parand Super-Speed motion picture negative film. The values obtained with these two materials were so nearly identical that they were averaged and are given merely under the designation *Ortho*. This result of course is to be expected, since it is well known that the spectral distribution of sensitivity is practically identical for Parand Super-Speed motion picture negative film.³ In the two columns under the general heading of *tungsten* are given the reflection factors as measured on panchromatic and orthochromatic film. It will be noted that for the red, orange, yellow, and yellow-green pigments the reflection factor as obtained on the orthochromatic material is appreciably less than that obtained with panchromatic; while in the case of the blue-greens, blues, and blue-purples, the orthochromatic reflection factor is appreciably greater than the panchromatic reflection factor; and in the case of those violets which contain red and blue in balanced proportions the reflection factors are about the same. The values obtained when the panels were illuminated with light from the plain carbon arc show the same general tendency as in the case of tungsten, but the difference between the factors on orthochromatic and panchromatic materials is not in general as great. In the case of the high intensity arc the same differences exist but are even smaller than in case of the plain carbon arc. Some of the values given appear rather erratic, but the factors which determine the photographic reflection factor of a particular color are so complicated that it is difficult to predict just what the reflection factor under any specified set of conditions should be.

It is thought that further data of similar nature relating to various materials commonly used in motion picture studio work will be of considerable interest and value. It is proposed therefore to extend these measurements to include a larger number of materials among which will be typical samples of the woods used in the manufacture of furniture and for the interior trimming of homes and public buildings. The twenty-five colors, relative to which data are given in this paper, represent but a small part of the panels which have been prepared for experimental purposes. The data relating to the remainder are not complete at the present moment and will be given in a later communication.

The author wishes to acknowledge his indebtedness to various members of the staff of this laboratory for assistance in carrying out the experimental work reported in this paper. The flicker photo-

meter used for obtaining values of visual reflection factors was designed and constructed under the supervision of Mr. E. M. Lowry. The measurements of values of visual reflection factors were made by him and his assistant. The photographic photometry involved in the determination of photographic reflection factors was carried out by Mr. M. E. Russell.

DISCUSSION

MR. CUFFE: Why can't the longer wave-lengths be obtained with arcs?

MR. JONES: I don't know whether there is a representative of the National Carbon Company here or not, but the quality of the light emitted by the carbon can be controlled, and I believe it is possible to make carbons having much better balance than is at present available. I believe that the manufacturer is limited to a certain extent by the materials which are available, and in many cases the materials which give selective emission of the desired wave-lengths are very expensive or may produce poisonous fumes. Hence, it is a question whether materials can be found by research which will produce the right result. Theoretically, it is possible; practically, it may or may not be.

MR. STEWART: In the last table is the value for vermilion 71 or 7.1?

MR. JONES: That should read 7.1. However, we get some very freaky results sometimes in the values. Some of the things we call red and which look red are reflecting a lot of violet, which has little influence on the eye but produces a high photographic reflecting power. Sometimes a color which is estimated to be very dull will show a high value and if it is examined spectro-photometrically the reason may be found.

MR. STEWART: You remember in my paper on make-up I mentioned this. Lavender is very useful in producing shaded effects for motion pictures.

MR. JONES: I am sorry we have not more data, but we are going to do some further work.

MR. SUMMERS: Were the neutral grays mixtures of black and white?

MR. JONES: They were exposed developing-out papers developed in a formula designed specifically to give a neutral deposit, so that they consist of finely divided metallic silver scattered over the surface of the paper and are photographically and visually non-selective.

THE TUNGSTEN LAMP SITUATION IN THE STUDIO

PETER MOLE*

THE general use of panchromatic negative film for the taking of motion pictures has introduced into the studios new problems in general illumination of the sets which in time will, no doubt, necessitate a change in present day lighting equipment.

The purpose of this paper is not to deal in technicalities or enter into a discussion as to the relative merits of either type of lighting; the incandescent, Cooper Hewitt, or arc light equipment, but will deal only with the development of the use of incandescent tungsten lighting equipment in Hollywood studios up to the present time.

It might be well, however, to review the early development of the high wattage incandescent lamps of the type used in the studios at the present time. It was around 1920 when Maude Adams first appealed to the General Electric Company for aid in developing a lighting unit which would enable her to successfully proceed with a new process for the taking of motion pictures in color. This was what really brought about the development of the 30,000 and 10,000 watt incandescent tungsten lamps.

Sometime later the Harrison Lamp Works of the General Electric Company made up some of the 3,000, 5,000 and 10,000 watt lamps at the request of the Eastman Kodak Company for use in their experimental motion picture studio at Rochester, New York. The results of their experiment with these lamps are covered in part by L. A. Jones' paper on "Incandescent Tungsten Lamp Installation for Illuminating Color Motion Picture Studios" as presented at the September 1925 meeting of your society.

With the introduction of panchromatic film the cinematographers made considerable use of low wattage incandescents for close-up work. The results obtained in this work were so satisfactory from the photographic standpoint as to lead to a desire on the part of the cinematographers to use this source of light to illuminate their entire set as well as the "close-ups."

It was at this point that they found there was no commercial equipment available to substitute for their present "arc spots" and "GE suns." The first equipment to replace the GE High Intensity 120 ampere spots and GE 150 ampere High Intensity Suns was

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furnished by Mole-Richardson, Incorporated, Hollywood, California, at the request of the Metro-Goldwyn-Mayer Studios through their chief engineer, Lewis Kolb, and consisted of ten 24 inch standard "sun" housings with pedestals equipped with a 24 inch long focus parabolic mirror with a base suitable for the 10,000 watt lamp.

In designing this equipment we were somewhat handicapped by the fact that it was necessary to follow certain specifications which called for the housings to be so designed as to be adaptable to both



FIG. 1. Double incandescent broadside lamp.

the 150 ampere high intensity arc elements as well as the 10,000 watt incandescent lamp. The efficiency of this unit could have been increased considerably, no doubt, if this equipment had been designed especially for the 10,000 watt incandescent lamp. These lamps have been used successfully in regular production. In some cases they are used on the sets in combination with the regular arc light equipment and in other cases used only with other incandescent lights. In both cases they have proven very successful.

About the time Metro-Goldwyn-Mayer were working with the 10,000 watt incandescents lamps, Warner Bros. Studios, under the supervision of F. N. Murphy, their chief engineer, were producing a picture called "The First Auto," using incandescent lamp units of not over 1,000 watts, and they used in a few cases some arc spot equipment. After viewing some of the scenes from this picture, I personally feel that a great deal of credit is due them for their aggressiveness.

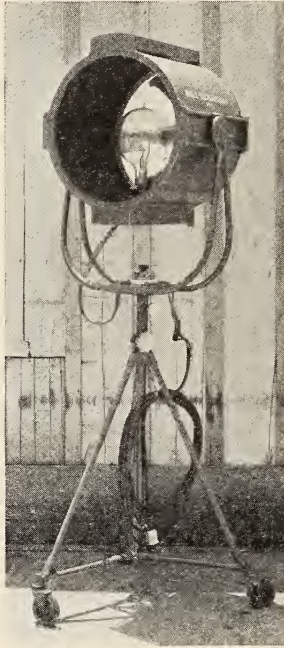


FIG. 2. Sun arc housing fitted with incandescent lamp.

In preparing the picture "The West Pointer," the De Mille Studio found it necessary to send a company on location to the West Point Military Academy at West Point, New York. It was found practically impossible to take the necessary arc light equipment to photograph the many interiors on the campus grounds. By the time the West Point Company was ready to leave, there had been developed a suitable lamp for spot light work, 18 inches in diameter, using a spun metal or glass parabolic mirror, and equipped

with either a 2,000 or 3,000 watt incandescent lamp. There was also used in front of the incandescent lamp a condensing lens to collect the light from the front face of the filament. By independently focusing the lamp toward the mirror so as to secure the size of spot required and then focusing the condensing lens with respect to the lamp, the spot was intensified, and also the so called "ghost" which is somewhat pronounced when spreading a beam of light from parallel rays was cleared up. Tests were carried on at the De Mille Studio under William Whistler, chief engineer, and Peverell Marley, chief cinematographer, who photographed "King of Kings," and as a result of those tests it was decided to use incandescent equipment for this particular location.

The equipment taken to West Point by the De Mille Studio consisted of

- 10—18 inch MR Incandescent Sunspots
- 20—Double MR Incandescent Broad-sides
- 15—Single MR Incandescent Broad-sides
- 6—Condensing Lens Spots

The 18 inch Sunspot used a 2000 watt G 48 lamp, the double broad-side used two 1000 watt T-20 lamps, the single broadside used a 1000 watt G 40. With this equipment they photographed all the locations except the chapel and the formal dance, and on account of the size of these two scenes it was necessary to use additional arc equipment, as no more incandescent equipment was available.

In addition to the above equipment the De Mille Studio has equipped every company operating in their organization with incandescent lighting equipment for close-up work. Before starting the picture "The Rose of Monterey" around June first of this year, Lee Garms, cinematographer of the First National Picture Corporation, working with Walter Strohm, chief engineer, made tests with the incandescent tungsten light and panchromatic film with the result that 75% of the entire production of this picture was photographed with this type of lighting. Arc light equipment was used where the sets were of such proportion that the available incandescent equipment would not entirely cover them to advantage. The operating costs of the electrical department for this particular picture with incandescents amounted to about 40% of the cost had the picture been taken with arc equipment.

From the results obtained in "The Rose of Monterey" the First National officials were encouraged to such an extent that they

purchased twenty-four additional 18 inch Sun Spots and other flood light equipment to fully equip one unit which is now in production making the picture "Man Crazy," photographed by J. Van Trees.

The second company to go on location equipped entirely with incandescent lights was the Sam Rorke unit of the First National starring Will Rogers in "The Texas Steer." During September this company will be shooting locations around the National Capitol at Washington, D. C.

Tests were made also at the Universal Picture Corporation Studio by Roy Hunter and Frank Graves. The results obtained from the incandescent lamps were so satisfactory that they now have on order enough equipment, consisting of the 18 inch MR Sunspots, broads and flood lights, to completely equip one company for this type of lighting.

After several weeks of testing and experiment on the part of individual cameramen, assisted by R. E. Nauman, chief engineer of the Famous Players-Lasky Studio, during the latter part of August a meeting of the cameramen was called at which the writer was present and discussed the different incandescent lighting units. It was unanimously decided that the results obtained from their tests justified their purchasing considerable incandescent equipment in order to carry on further tests and to carry on certain of their regular production work with this type of lighting.

The Studios' officials, cinematographers, and electrical supervisors are to be commended for the manner in which they have grasped this new form of lighting. All of them have manifested great interest, and in every case the writer has received the greatest amount of coöperation possible when running tests or making demonstrations. Indebtedness to The General Electric Company through F. E. James and E. P. Mackee of their Los Angeles office is hereby acknowledged because of their assistance and coöperation in this new branch of studio lighting.

It must be remembered that while the incandescent tungsten lamps have been used for some time for "close-up work" and "stills" their use in the studios for general motion picture production work has been limited to only about nine months.

Reviewing this article and analyzing the work being done by each studio, one can easily see that a great future is ahead for the incandescent equipment. It may take considerable time for the different departments, such as the electrical, photographic and laboratory, to

adapt themselves to the new conditions, but this is gradually being done, and I do believe greater strides will be made in incandescent tungsten lighting in the near future.

DISCUSSION

MR. BEGGS: About a year ago I tried to calculate the theoretical costs of lighting a studio with mazda lamps. At that time it was felt that mazda lamps were impossible, but calculations made theoretically showed that the costs were approximately the same as for arcs. Now, the film is a little faster for incandescents, and labor costs have been calculated closer, so that the figures I published at that time do not necessarily apply for mazda lamps although at that time it was about a toss-up for cost for lamps, fixtures, and labor. Since that time we have been asked to produce a metal reflector. It is not so efficient as silvered glass, but it is indestructible, and chromium has been found to be the most successful plating. The advantages are chiefly that it is easily cleaned. Chromium is going to be very popular as a surface plating material. Probably you noticed that the Kodascope projector used it, and it is being used in the lighting field for industry.

I should like to ask Mr. Farnham about the over-voltage operation of lamps. Any of these incandescent lamps can be burned with over-voltage with reasonable assurance that it will give fair photographic performance, but it may destroy the lamp, and there should be an agreement among studio engineers, I believe, concerning the exact over-voltage which should be used.

Another point is the avoidance wherever possible of these extremely expensive lamps; \$175 is the present price of the 10 kilowatt lamp with 100 hours' life. The same light flux can be obtained from ten 1000-watt lamps for \$2.50 each, which gives a different total price, and it seems unreasonable that studio engineers should insist on using the very expensive lamps. I think they might get together a symposium on the use of incandescent lamps for studio engineers.

MR. FARNHAM: With reference to operating lamps at an over-voltage, the studios now working with incandescent lamps operate them from the same source of supply that they operate their arc equipment, and hence it is not practicable to operate the lamps at other than the voltage of the circuit without causing trouble on other sets that are using the same source of supply.

The light output of an incandescent lamp operating at from 250 to 400 hours' life has the correct color characteristics for use with panchromatic film, and if they were operated at an over-voltage, a relatively greater increase in the blues and violets would result, and the color rendition would not be correct. Instead of over-voltaging the lamp at the time the picture is being taken, I suggest the practice of operating lamps at an under-voltage during rehearsing and at times when it is not necessary to expose the film, and then before the picture is to be taken the lamps should be brought up to normal voltage.

In considering future practice where the lamps are operated directly from alternating current source, it would be a simple matter to install a portable induction regulator between the supply circuit entering the building and the particular set on which it is desired to control the current. This would make it possible to operate the lamps at an under-voltage until the time to make the picture, when they could be quickly brought up to full voltage. The use of this device would likewise permit bringing lamps from total darkness to full brilliancy or from full brilliancy to total darkness for special lighting effects, duplications of sunrise and sunset scenes, etc.

With reference to Mr. Beggs' point that it would be more desirable to use ten 1000-watt lamps instead of one 10,000 watt lamp; this might be practical in some cases, but there are many instances where it is desired to create the effect of strong sunlight streaming in through a window or door, and the intensity of this source must be considerably greater than that of the other light source illuminating the set. For this purpose a single source of high-wattage such as a 10 kilowatt lamp would be required. Ten 1000-watt lamps would be quite out of the question because they would create ten individual shadows and spoil the illusion of sunlight.

MR. ISAACS: I should like to ask Mr. Farnham what the advantage would be of cutting back from DC to AC when the latter gives flicker.

MR. FARNHAM: A mazda lamp operates equally well on alternating or direct current. The studios would naturally not wish to discard their existing motor generator sets, but as the present equipment becomes obsolete or greater lighting capacity is required, they would gradually shift to AC operation and thus remove the heavy investment in substations and the necessary attendant which rotating equipment requires. With regard to flicker on alternating current

circuits, due to the relatively small size filament wire of the 100-watt lamps and those of lesser wattage, there is a noticeable flicker when the lamps are operated on 25 cycle currents. On 60 cycle currents this flicker cannot be detected with the eye, but it can be observed by stroboscopic methods. However, as we increase the wattage of the lamps and hence the diameter or mass of the filament wire, the heat storage capacity of the filament becomes greater, and the fluctuations of the light, due to the cyclic variations of the current, becomes less. From tests which we have conducted using a special stroboscopic device, we find that fluctuation of the light disappears with lamps of 500-watt, 115-volt ratings and above on 60-cycle circuits. In the studio district, 50-cycle circuits are the rule, so that it is probable that the 750-watt lamps would mark the dividing line between flicker and non-flicker. Since all of the lamps employed in studio lighting service are of 1000 watts and above, I can assure you that there will be no possibility of flicker caused by the shutter getting into synchronism with the alternating current cyclic changes.

MR. BAUER: Some years ago Westinghouse went into the problem of sufficiently heavy filaments in incandescent lamps. As Mr. Farnham says, it happened frequently that the synchronism mentioned was noticeable on the screen as a decided flicker. The result of their investigation was that they brought out a transformer with a 20-ampere 20-volt light, which is equivalent to 400 watts. In an ordinary 400-watt incandescent lamp, the flicker would persist, but with the 20-volt 20-ampere lamp, the filament was sufficiently heavy to prevent this.

MR. CRABTREE: I should like to mention that in the studio in Rochester for taking color motion pictures it is our practice to burn the lamps at under-voltage during arrangement of the set and at over-voltage only during actual exposure. This is done by means of rheostats.

MR. BEGGS: All the prize fights are photographed in the light of incandescent lamps. At Chicago they used 44 one thousand watt lamps in 44 reflectors. These burned at normal voltage and were of the ordinary type used for industrial lighting. Had they operated the lamps at over-voltage as in the Kodak studio, the total number of lamps could have been reduced about 30% using the same type of lamps and fixtures.

Recently, we received an order for lamps from a studio on the Coast asking for 2000- and 2500-watt lamps. The particular types

described on the order are designed for high intensity spot lighting. They will give an average life of 50 hours each, and it will be our job to change the order to something more reasonable for studio lighting. Tomorrow we may have another order from another studio for lamps just as poorly suited for their work. The effect photographically is excellent, but the cost is excessive, and the chances are they will over-volt them. You should not over-volt a lamp designed for the extreme intensity of the 50-hour lamp, and yet I am quite sure that unless steps are taken by our representatives, that will be done. Steps can be taken now in advance, and Mr. Farnham and others could save a good deal of money in this way.

I think Mr. Farnham should tell the members about the heat of Mazda lamps, on which he has had direct experience.

MR. FARNHAM: In my work in the various studios on the use of incandescent lamps, the question of heat from these lamps has never been raised. I have made inquiry on this point from the actors and other people employed on the sets, and the usual reply was that they had not noticed any particular difference. The incandescent lamp equipment does not require ballast resistances which dissipate a considerable quantity of heat and hence causes an increase of temperature in the vicinity of the set. The decrease in make-up required when incandescent lamps are employed unquestionably accounts for the greater comfort of the actors when working on sets lighted by incandescent lamps.

MR. ROSS: Do not the fast lenses now generally employed assist materially in reducing the illumination required?

MR. FARNHAM: Yes. Heretofore, the standard lens has been the $f/3.5$, and the studios are now using $f/2.3$ or $f/1.8$ or 1.9 , and one is experimenting with $f/1.5$ with very satisfactory results.

FACTORS WHICH AFFECT THE CONTRAST OF A LENS IMAGE IN THE MOTION PICTURE CAMERA*

CLIFTON TUTTLE AND H. E. WHITE

THE accurate reproduction of object contrast by the lens image is the optical desideratum in photography. To fulfill this requirement, it is necessary that each area in the image shall receive light from only the corresponding area of the object. If any light other than true image-forming light falls onto the image, the contrast relations will be altered. A uniform distribution of non-image forming light over the image results in a decrease of image contrast.

In practice several factors may give rise to the presence of extraneous light: light leaks in the camera, lens flare (i. e. reflections at glass-air surfaces of the lens), reflections at metallic surfaces of diaphragm, lens mounting and camera interior, and diffusion due to foreign particles within the glass and on the surface. The first of these is avoidable by proper construction of the camera and by care in its use. The second it is impossible to avoid entirely although by careful design of the objective its effect may be minimized. The third factor is more difficult to control and of greater magnitude than is generally supposed, but by proper precautions its effect may be reduced to negligible proportions. The fourth factor is dependent principally upon the cleanness of the lens.

Lens Flare

The effect of lens flare upon the image contrast is small in properly designed motion picture lenses containing not more than three components. Although it may be measurable under laboratory

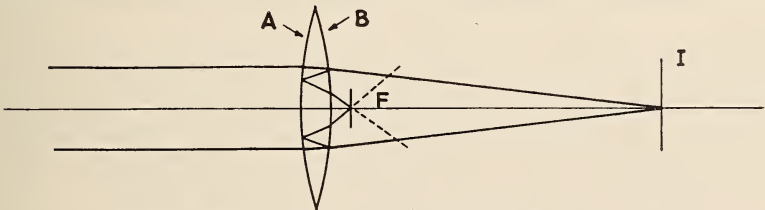


FIG. 1. Diagram explaining the cause of lens flare.

conditions, for the great majority of practical cases it need not be considered as a serious menace to image quality. The conditions

* Communication No. 329 from the Kodak Research Laboratories.

causing flare are shown in Fig. 1. It illustrates a simple lens which is forming an image of a distant object in the plane I . Light from the object is incident at the surface A . A portion (about 4%) is reflected at this surface in the direction of the object. The remainder, except a very small amount lost by absorption, passes through to surface B , where a second reflection takes place. This second reflected component returning in the direction of the object suffers another reflection at surface A . The light resulting from a secondary reflection at surface A , amounting to about 4% of 4% or $1/625$ of the original, goes to form the primary flare image at F . The image F may lie at any position with respect to I , either in front of or behind it, depending upon the curvatures of the lens surfaces and upon the refractive index of the glass. If it lies in the same plane as the image I , a flare spot results and the contrast of the image of this part of the object may be considerably affected. If it lies either close to the lens or far behind it, the flare light will be fairly well distributed over the image area.

In either of these cases of uniform distribution, the maximum effect upon contrast may be computed, for at the most $1/625$ of the average image brightness will be added to the brightness of each portion of the image. Suppose that the highest brightness of the object measures 8000 millilamberts and that of the shadow portion is 100 millilamberts. The object contrast will be 80. If a single lens with an $f/8$ aperture is used, the image brightness due to true image-forming light will be about $1/100$ of the object brightness—80 and 1 respectively for highlight and shadow. To each of these values will be added about $1/625$ of the average image brightness. The average image brightness depends upon the type of picture. In seascapes or snow scenes containing a great deal of sky, the average image brightness may be nearly as great as the highlight brightness. For the usual case, however, the average will be not over 25% of the highlight value. If an average brightness of 20 millilamberts is assumed for the foregoing case, $20/625$ millilamberts will be added to image highlight and shadow. The contrast ratio then becomes $\frac{80.032}{1.032} = 77.5$. Here it is assumed that *all* of the flare image light strikes the true image, hence the effect upon the contrast computed above will be a maximum for the assumed condition of uniform distribution. If the flare light is distributed throughout a wider angle than that subtended by

the real image, as is usually the case with a well designed objective, the contrast reduction will be less.

A fairly accurate estimate of the maximum flare effect of any number of lens elements can be computed by assuming a pile of plane parallel plates separated by air instead of a number of curved surface elements with intervening air spaces. It can be shown that

$$\frac{I_R}{I} = r^2 \left\{ 1 + \frac{1}{1-t^2} \left[2(n-1) - \frac{t^4(1-t^4(n-1))}{1-t^2} \right] \right\}$$

where I_R = light transmitted after reflection at back and front surfaces of plate

I = directly transmitted light

$$r = \left(\frac{u-1}{u+1} \right)^2 = \text{Fresnel reflection coefficient } (u = \text{refractive index})$$

$$t = \frac{4u}{(u+1)^2}$$

n = number of plates

This formula assumes normal incidence and neglects reflected light of higher orders and optical absorption within the glasses.

Substituting in this formula for various numbers of plates and assuming a refractive index of 1.5 gives the results in Table 1.

TABLE 1

Ratio of Re-reflected Light to Total Transmitted Light for Various Numbers of Plates

n	$F = \frac{I_R}{I}$
1	0.0016
2	0.0093
3	0.021

Goldberg¹ has found experimentally a value considerably in excess of these computed maximums. Goldberg expressed the flare-forming characteristics of a lens as "Specific Brilliancy," which he defines as $\log_{10} I_s/I_r$. I_r and I_s under the described conditions of the experiment seem to correspond to our values I_R and I respectively. Stating Goldberg's value of specific brilliancy in terms of our value F as used above, his data gives

¹ "Der Aufbau des Photographischen Bildes," Enzyklopädie der Photographie, Vol. 99.

N	Specific Brilliancy	F (computed)
1	2.2	0.0063
2	1.8	0.016
3	1.5	0.032

Apparently in the case of the objectives measured by Goldberg, either the flare light was concentrated about the area measured or there were present internal reflections other than those at glass air surfaces.

Non-image Forming light due to Internal Reflection other than lens flare.

If the lens of the motion picture camera is unprotected by a hood or lens shade of some kind, light other than that used to project the image on the gate will enter the lens. Even if the barrel and diaphragm and the interior of the camera are carefully blackened, some portion of this unnecessary light will eventually—perhaps after several reflections—fall on the film aperture.

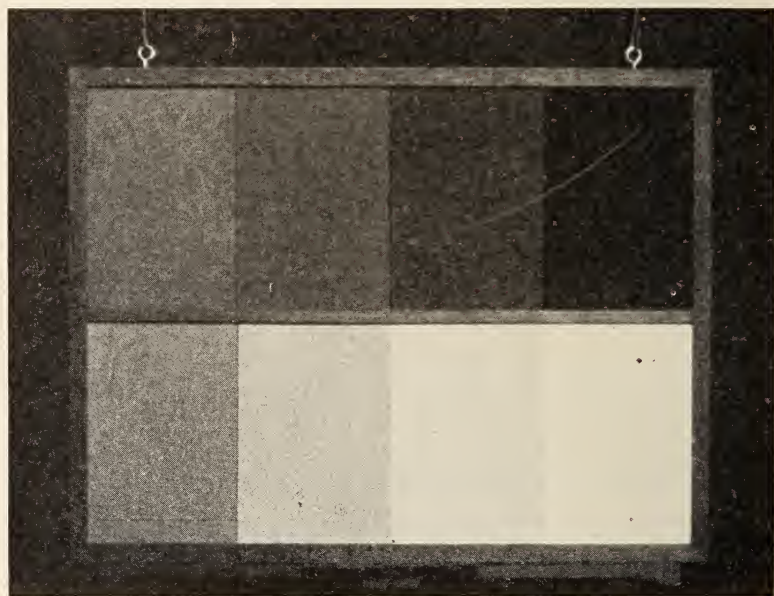


FIG. 2. Test object containing eight panels.

The following experiments were tried to ascertain the magnitude of non-image forming light which occurs with the unprotected lens and to get a practical estimate of the amount of lens flare existing in an objective of standard quality.

A set of eight neutral colored panels were prepared and mounted in a panel board (Fig. 2). These panels ranged in reflecting power from 0.433 to 0.015.

TABLE 2
Photographic Reflecting Power of Panel Areas.

Area No.	1	2	3	4	5	6	7	8
	0.433	0.274	0.173	0.101	0.069	0.051	0.032	0.015

A Bell and Howell standard camera with a three component lens of good quality was mounted in front of this panel at such a distance that the image of the panel board just filled the motion picture frame. Behind the panel board were hung successively three background drapes of different reflecting powers. The backgrounds were large in comparison to the panel board. They subtended an angle of about 100° at the lens. The panel board was uniformly illuminated from the front, hence the reflecting powers of the panel areas (measured photographically) were proportional to their brightness.

The test object was photographed using four different lens stops, changing the background in each case to alter the amount of unnecessary light which entered the lens. In order to detect the presence of flare spots, the arrangement of areas within the panel board was systematically altered so that each test area occupied consecutively all of the eight different positions.

By sensitometric methods, it is possible to determine the brightness of an image resulting in a given negative density. The developed images were measured on a densitometer and subsequently the data were recorded in terms of brightness. A typical set of data are given in Table 3.

TABLE 3
Relative Brightness of Test Object Images (Lens at f/32)

Area No.	1	2	3	4	5	6	7	8	<i>Ratio of Peripheral Brightness to Average Object Brightness</i>
	0.603	0.390	0.246	0.156	0.117	0.102	0.078	0.061	7
	0.597	0.367	0.235	0.139	0.096	0.077	0.057	0.042	1
	0.586	0.351	0.222	0.128	0.082	0.065	0.042	0.024	0.25

The only variable in this set of data was the peripheral background brightness. Since none of this area was included within the film

image, any difference must be due to reflected peripheral light striking the film. That there is a great difference in contrast may be seen at once by comparing the ratios of highest to lowest brightness in the

three cases: $\frac{0.603}{0.061} = 10.1$; $\frac{0.597}{0.042} = 14.2$; $\frac{0.586}{0.024} = 24.2$. In the last

case, where a black peripheral background was used, the image contrast approaches close to that of the object. Obviously, light from areas surrounding the true image can seriously affect contrast. A

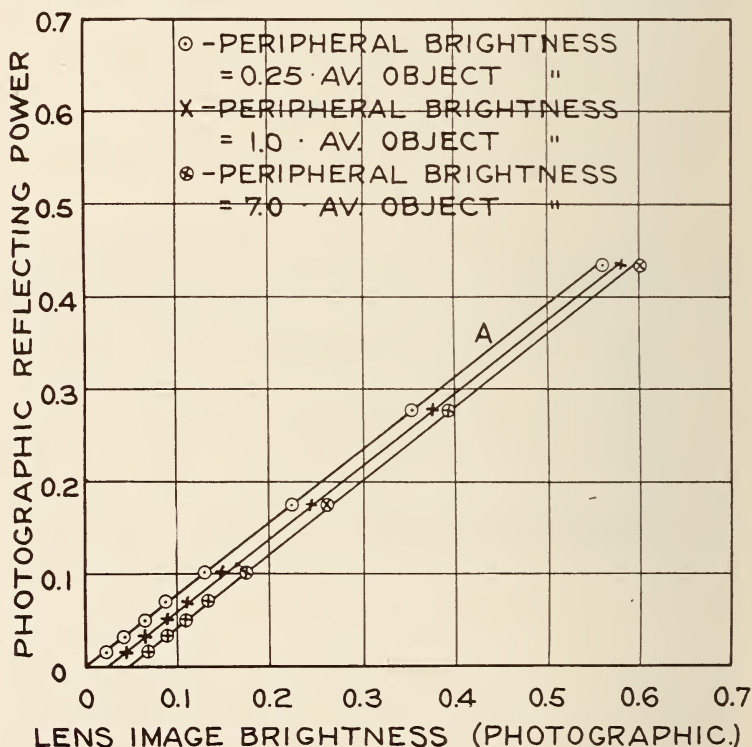


FIG. 3. Curves showing the relation between object and image brightness.

graphical representation obtained by plotting the data of Table 3 against the photographic reflecting power (Table 2) is shown in Figure 3. Here it can be seen that the addition of non-image forming light takes place rather uniformly over the entire frame. Since it is a uniform effect, the intercepts of these curves on the image brightness axis are indicative of the amount of non-image forming light.

The intercept is the amount of veiling light which would be present over the image of a perfectly black object.

The intercepts of all sets were found by the least square method. The agreement between similar sets is exceptionally good considering the numerous possibilities for experimental error which the method involves. Table 4 summarizes the average data for the four different lens openings. Since the absolute value of the intercept depends upon the intensity of the image-forming light which is different with different lens openings, it seems best to express the amount of non-image forming light by means of the ratio between the intercept and the average image intensity. This ratio is denoted by R in Table 4.

There is present only a small amount of non-image forming light in all four cases where the background brightness was low in comparison to the average object brightness. As a matter of fact, the intercept of the curves, such as A in Fig. 3, was in all cases less than the probable error of measurement.

TABLE 4

Relation between Brightness of Non-Image Forming Light and Average Image Brightness for Various Conditions.

<i>F-Number of Lens Stop</i>	<i>Ratio of Peripheral Brightness to Average Brightness of Test Object</i>	<i>R = Ratio of Image Brightness Intercept to Average Image Brightness</i>
32	7.00	0.194
32	1.00	0.094
32	0.25	0.003
11	7.00	0.133
11	1.00	0.072
11	0.25	0.001
8	7.00	0.110
8	1.00	0.039
8	0.25	0.003
3.5	7.00	0.230
3.5	1.00	0.029
3.5	0.25	0.004

There is no consistent variation of R with the change in lens opening. The uncertainty of the variation in effective area of reflecting surfaces within the lens makes it impossible to guess at any correlation.

It can be stated that for this particular lens, at least, the flare image light originating in the object is distributed throughout such a wide angle that the effect upon contrast of an average subject, such as is represented by the test object, is negligible. On the other hand, the presence in the camera of light from the peripheral area has a very serious effect. Sky brightness in exterior pictures, for instance, might in many cases be enough greater than the average object brightness to reduce the image contrast by a factor of from three to five. An even greater reduction of contrast is possible in studio work where light from bright sources outside the object area may enter the camera. It has been pointed out in a previous paper² by one of the authors and L. A. Jones that contrast reduction due to the presence of non-image-forming light in a screen image cannot be entirely compensated by laboratory treatment of negative and positive. The same argument will hold in the present case. Though a flat picture may be considerably improved by increased development of negative and positive, the results cannot approach the quality of a correctly exposed negative free from non-image-forming light fog.

Lens Shades

Since the exclusion from the lens of light which is not used in the image appears to be of importance, it seems desirable to give some consideration to the means by which this may be accomplished. In some cases, as in the making of titles and in some studio sets, the brightness of the peripheral border can be controlled. The title board may be surrounded with black cloth as was done in the experiment just described. In studio photography care in the darkening of walls and windows which lie outside of the field of the lens would undoubtedly add to the brilliance of the picture.

In most cases, however, the use of a lens hood is the only solution, for the amount of non-image forming light striking the lens can be controlled only in this way. To limit the cone of light entering the lens, a rectangular hood seems the most desirable. A rectangular hood attached to the camera cannot, of course, exactly limit the field without vignetting the picture. It must always be somewhat larger than a frame enclosing the pyramid whose apex is the lens center and whose sides are the rays converging to the center. The following

² "The Effect of Projection Lens Flare upon the Contrast of a Motion Picture Image" by Loyd A. Jones & Clifton Tuttle, *Trans. S.M.P.E.*, 25, 153 (1926).

approximate relation will give the size of the frame nearly enough for practical purposes:

$$\text{Length of Rectangle} = \frac{\text{Length of Hood}}{\text{Focal Length of Lens}} + \text{Aperture of lens};$$

The width of the lens aperture is found by dividing the focal length by the *F* number of the lens. The longer the lens hood, the less will be the amount of extraneous light to enter the lens. The length of the hood is limited by practical considerations, but the beneficial effect of the hood, at least for short focus lenses, is very marked even with a short protecting hood.

A subject having a visual contrast of about ten to one was photographed out-of-doors using a two inch focal length lens and various types of lens hoods. With no hood to protect the lens from the light of the surrounding sky, the contrast of the image was reduced about 40%. With a hood fourteen inches long, rectangular in shape, the reduction in contrast was less than 5%, and with a cylindrical hood of the same length the reduction was about 10%. As the hood was shortened and the hood openings made correspondingly smaller in size, the beneficial effect was somewhat decreased. However, even with a two-inch hood supporting a rectangular aperture in front of the lens, the image contrast was only 20% less than the object contrast value.

Disturbance of Contrast due to Diffusion

Under the general heading of diffusion may be grouped a number of causes such as dust, finger prints, air bubbles, and imperfect polishing. Data regarding the magnitude of these effects upon contrast is almost valueless since so much depends upon the particular case. A single well-defined finger print upon the surface of a lens may reduce the contrast of the image to one-half of that formed with a clean lens. Dust and air bubbles if present in great enough quantity to scatter light may decrease the contrast still further. The effects of diffusion are in practice always superimposed on the disturbances caused by internal reflection and lens flare. That they may be made of negligible consequence is indicated by the almost perfect reproduction of object contrast which was attained in the experiments previously described.

DISCUSSION

MR. MATTHEWS: In the tests described with the lens hoods, I don't know whether you mentioned whether a special type of background was used or whether they were merely photographed against the sky.

MR. TUTTLE: They were photographed out-of-doors with the sky occupying almost the entire peripheral field, while the test object occupied the entire object area.

MR. BRIEFER: I have just made a rough calculation and find that about one-thirtieth of the initial brightness is added to the differential. Have you found the additive effect of the light that is not part of the object to be the same for the high densities as for the low densities?

MR. TUTTLE: The non-image forming light is quite uniformly distributed as may be seen by reference to figure 3.

ANIMATED TECHNICAL DRAWINGS

J. A. NORLING*

The animated technical drawing or technigraph is a recent development which has grown out of the animated cartoon. Its chief use is to illustrate by means of motion the operation of devices and machinery while providing in text and action technical descriptions of the same, and in addition it finds a steadily increasing use in other phases of that type of motion picture which is classified as "educational."

The animated technical drawing is essentially designed to illustrate operations or ideas in motion that cannot readily be shown by means of the ordinary standard motion picture. They inject into an illustration of objects a living quality, adding a fourth dimension of time in relation to their spacial components. The efficacy of depicting things in this fashion is too well known to need much emphasis. Consider the application of the technigraph to unseen or invisible parts of a machine to illustrate its complete operation. The use of animation makes prosaic charts, graphs, and maps into living pictures, increasing their interest value a hundred fold.

All mechanical devices operate throughout a more or less well-defined cycle consisting of a series of actions in predetermined order. A word description of actions lacks among other things the definitely clear conception of the time-space arrangement of objects. Still pictures can be used in part in many cases to clarify descriptions, but they also lack the quality of satisfactory analysis of the relation of objects to the time element. With animated technical drawings the relation of objects in the sense of time and space dimension can be clearly illustrated, where a still picture or a word description would fail to convey anything but a meager conception of these things. Special models of machines or devices are better than still pictures, but they are usually hampered by certain physical limitations that prevent giving a complete demonstration. One can construct a model of a steam or gasoline engine and thus demonstrate most of the mechanical operations, but it is difficult to make a model that will show other physical conditions connected with the operation of the device, such as the flow of steam, the explosion of gas, the conditions of internal pressures, etc. The technigraph does not suffer these

* Loucks & Norling, Inc., 723 Seventh Avenue, New York City, N. Y.

physical limitations. Functions of a machine, invisible on a model, can be clearly illustrated by this new medium. The theories of the flow of electric current, the circulation of the blood, astronomical theories, psychological studies, physiological functions, geological formations, and a host of other things have been successfully illustrated by means of the technigraph although they are difficult to describe clearly in any other way.

Many people have realized the advantage of this new medium to disseminate knowledge. Manufacturers have had many films made for both sales and educational purposes, but not in all cases have these films delivered their message clearly. The reasons for this failure may be equally divided between the user and the producer. The user of the film often does not realize which is the best way to show things in motion pictures. In many cases, the producer is just as apt to miss. Lack of proper training and unfortunate experience with poorly conceived films are usually the reasons for this shortcoming.

When a film fails to tell its story, it is often due to the endeavor to tell too much in a limited footage. The desire to make a snappy production out of a mechanical film is often the reason for its failure as a medium of accurate, clearly conceived information. I do not mean that a little comedy to lighten up the film is always taboo; I mean that in many cases it is extremely difficult to introduce these outside elements without detriment to the film. Some films contain an insufficient amount of animation. The actions are not on the screen long enough for the audience to grasp them thoroughly.

If the producer is conscientious and able, and his client sees the value of reasonably complete descriptions, he will make a product that will accomplish its purpose. On the other hand, should the producer be incapable, the picture is doomed to failure. Animation is expensive when properly made, and slipshod or improperly conceived drawings show up quickly. Cutting down in quantity of drawings often means a reduction in quality of the film at the same time. A technigraph film requires complete actions, thoroughly described and repeated sufficiently to convey clear understanding. Given a properly conceived and executed technigraph the manufacturer has available an unexcelled medium for describing his product.

The educator early realized the benefits of visual instruction, and when the motion picture appeared there were many who conceived it to be the ideal educational medium. The appreciation ac-

corded the animated technical drawing by some educators indicated at once that here was a link that would make possible a still wider use of educational films. There has been hitherto much disappointment from the use of some educational films. Here again the blame should be divided—because some films upon which educators have worked are as bad as some films that were produced without their collaboration. Seeing the result without analyzing the cause, many educators have jumped to the conclusion that the use of motion pictures is very limited and of small value as an instructional medium. On the other hand, some educators insist that complete descriptions are on the whole undesirable, as the student should be trained to think for himself. He is right in a measure, yet a teacher must impart a certain amount of information. The motion picture can give information in a fashion any other medium lacks.

One fact, however, stands out prominently in spite of these dissenting views—we have discovered a medium of instruction so new and so unique that no one actually knows anything about the way it should be used.

The motion picture that uses technigraphs can and does impart information in the fullest measure. One thing must be kept in mind, i. e., make the films comprehensive enough. Short films containing mere bits of sketchy information are of very little real value. They may provide the student with a few minutes of relaxation from study; their use, however, often merely consumes valuable time. It is unfortunate that most educational films have been sketchily conceived. No wonder educators sometimes question their value. They would be prone to question the value of a textbook if it were compiled in a similar fashion. Animated technical drawings can be used in instructional films to provide the thoroughness that they need. That is their chief use; and experience, though limited, among even those who have been engaged in the work for several years, has shown their possibilities in this respect.

It may be of interest to many to know how the animated technical drawing or technigraph is made. The general methods used in making animated technical drawings are similar to those in use in the production of animated cartoons, but there are certain distinct differences. For instance, where the average animated cartoon depends on the use of transparent sheets, such as celluloid or glass upon which to make the drawings, technigraphs seldom require the use of

celluloids. In planning production, the following general operations take place:

- 1 Scenario
- 2 Layout
- 3 Animation
- 4 Photography
- 5 Assembly of the first print
- 6 Corrections and additions (necessary in 90% of all productions)
- 7 Final assembly

The scenario is not like a scenario written for the motion picture stage. A technical scenario is often only a skeleton around which to build a picture. The more efficient the production is, the less of a skeleton the scenario seems to be. Some scenarios are so sketchy that it is a wonder that any sort of cohesive picture ever results from them. Here is a sample of the sketchy scenario:

(1). Make a view of a simple cylinder and show the parts, indicating with labels, etc.

(2). Show how the flywheel is turned and substitute the driving wheel of a locomotive, etc., etc.

The information that is given above is supposed to give the animator the information necessary to enable him to make a film running to perhaps 700 or 800 feet. It is a wasteful procedure to submit such vague specifications because it leaves the animator to do all the research work. If he does not possess a sufficient background of technical knowledge or experience, he will commit some awful crimes that remain under cover until the first screening which may take place after the work has been in process for weeks or months.

A scenario for animation should contain all the information possible, together with footage lengths, text of titles, labels, and a thorough description of the actions. A combined scenario and continuity, such as is required if there is to be any efficiency in production, should follow a form similar to the following:

TITLE 1. The work of the locomotive steam engine is to turn the driving wheels. Length, 8 ft.

SCENE 1. Close-up of the drivers of a locomotive made from an angle approximately 45 degrees in front and to the side of the locomotive from another engine moving at the same speed. Straight photography. Length, 15 ft.

TITLE 2. The elements of a simple steam engine. Length, 6 ft.

SCENE 2. Drawing of simple cylinder showing simplified admission port. Hold 2 ft. Introduce arrow and indicate cylinder. Hold 1 ft. Cross dissolve in; note: "Cylinder" in eight frames and hold 2 ft. Cross dissolve out, leaving arrow

in place. 8 frames. Hold arrow 1 ft. Move arrow to indicate piston and hold. 1 ft. Cross dissolve in; note: "Piston" in 8 frames and hold 2 ft. Cross dissolve off; note in 8 frames and hold arrow 2 ft. Move arrow to steam chest and hold 1 ft. Move arrow down through port and hold 1 ft. Cross dissolve in; note: "Port, through which steam enters the cylinder" in 8 frames and hold 6 ft. Etc., etc.

If every possible action is planned in advance, with closely estimated lengths of footage, mistakes or overproduction are reduced to a minimum. It has been the unfortunate practice to overshoot 50% to 100% and then cut down. This waste is not necessary. Although some cutting is always necessary, it is surprising how little is required when the scenario is planned in this minute detail. The picture can be planned to reduce waste footage to as low a figure as 7% or 8%.

The layout is a series of pencil sketches of the parts to be animated. In the layout for the scenario herein described, we would make a sketch of the cylinder and note the number of drawings required to carry the moving parts through a complete cycle. The layout would contain the instruction:

"Make a hook-up cycle of 64 drawings with steam actions for each position. Plan to photograph actions on 4 frame dissolves, 2 frames, 1 frame, and every other drawing on 1 frame exposures."

This information relating to speed of action, etc., is necessary so that the animator will know in advance what approximate speeds are required in the finished film. The animator learns to think of an action moving a certain distance on "ones" or "twos," as he calls it, and his experience tells him what must go into the drawing or what must be left out to minimize jumpiness in the final result. On slow actions he must exercise much more care in draughtsmanship than on fast actions. Some fast actions actually require a distortion to make them look natural.

Before the drawings are photographed, the animator makes out an "exposure sheet." In our practices we use the scenario-continuity with an exposure sheet combined. The advantage of systematized planning is reflected in the simplicity with which the drawings can be photographed. There is no need for the camera operator to call on his own initiative in photographing, and in this way it is possible to eliminate one of the drawbacks attendant upon the production of animation.

The most carefully planned production sometimes requires additions after the first assembly. Usually these changes are merely the

addition of a few explanatory labels and titles; very seldom is it necessary to make additional drawings. This is not the case, however, where the planning has been haphazard. In such productions the greater part of the film must often be rephotographed three or four times.

A person who has had experience in manufacturing is always astonished at what seems to him the lack of efficiency in motion picture theatrical production. He cannot understand why a director in a recent production should shoot hundreds of thousands of feet and succeed, only after months of work in the cutting room, in getting the picture down to twenty reels, a length totally unsuited for public showings. Another genius was called in to labor with this picture in the endeavor to hammer it down to a reasonable length. Many weeks more were lost. The manufacturer knows that there is no real reason for such inefficient procedure. However, in the production of animated drawings, very little inefficiency will soon make itself severely felt. The industrial film producer cannot pass excessive costs along to the public. Each picture must be produced in the shortest possible time with the least possible waste and at a reasonable selling price.

A COMPACT MOTION PICTURE DENSITOMETER*

J. G. CAPSTAFF AND R. A. PURDY*

A DENSITOMETER based on the inverse square law was described before this Society at the meeting held at Ottawa in 1923.¹ While this instrument has proved eminently satisfactory, it was deemed advisable to construct a densitometer which would be more portable and would be relatively inexpensive.

In designing such an instrument, an attempt was made to realize the following conditions:

1. The densitometer should be capable of measuring silver deposits ranging from a density of 0 to 3.0, the latter being the highest density normally met with in motion picture work.

2. The densitometer should also be capable of isolating and measuring $1/2$ sq. mm. at any point within the limits of the picture frame; uniform areas of density in motion picture images vary from $1/2$ sq. mm. or smaller to the entire frame.

3. The photometric field should always be maintained at a fixed illumination; that is to say, the light reflected from the comparison surface should be a constant and the light transmitted by the tone, matched to it. Where the comparison beam is reduced in intensity when high densities are measured, reading becomes difficult.

4. A single light source should be used both to illuminate the density to be measured and to furnish the comparison beam. Errors due to variations in the intensity of two sources are consequently eliminated.

5. Measurements should be made so that true contact printing values for neutral films are obtained. As a photographic deposit consists of silver particles, light incident upon a photographic image is partially transmitted without deviation and partially scattered, so that a different value for any given density is obtained depending on whether the density is measured with specular or diffused light. As the light sensitive surface is in contact with the negative under the usual conditions of motion picture printing, the scatter effect is negligible.

* Communication No. 331 from the Kodak Research Laboratories.

¹ "A Motion Picture Densitometer" by J. G. Capstaff and N. B. Green, *Trans. S.M.P.E.*, No. 17, p. 154 (1923).

6. The scale of the instrument should read directly in density values.

7. The instrument should be designed with a view to ease of working, compactness, and low cost.

The photometric arrangement designed to fulfill the preceding conditions is shown diagrammatically in Fig. 1. It has the following essential elements: a light source *A* both for illuminating at *H* the density to be measured and for furnishing the comparison beam; a photometric field at *G* obtained by the aid of the mirrors *B*, *D*, *F*, and *G*; a photographic wedge *W* for decreasing by a known amount

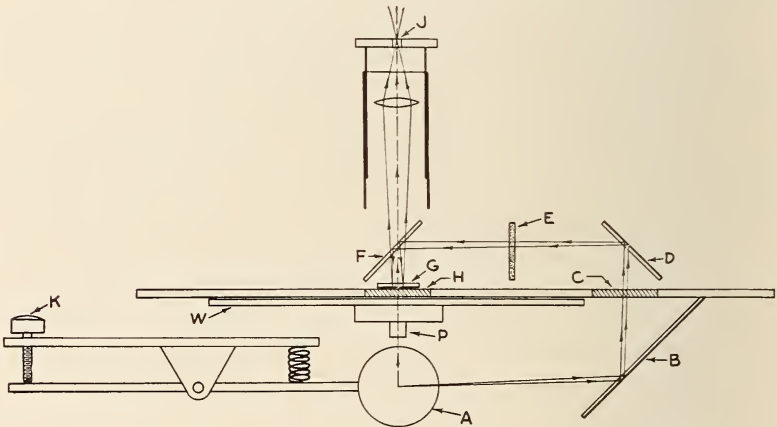


FIG. 1. Diagram of densitometer optical system.

the intensity of the light illuminating the density; and an eyepiece *J* for viewing the photometric field.

A general view of the instrument is shown in Fig. 2 and working drawings in Figs. 3 and 4. The essential parts are mounted on 1/4 inch aluminum, this aluminum also acts as a cover for the instrument case. The interior of the box is painted white with the exception of the aluminum cover, which is black. The light source *A* is a 5 volt, 4 ampere, 32 candle power automobile headlight lamp. This type was chosen because it would burn in a horizontal position without the filaments sagging. In order to permit the use of 110 volt A. C. line, a small toy transformer is introduced into the circuit. One beam of light from this lamp passes through the circular silver wedge *W* (Fig. 1), rotating on the pin *P*. The photographic wedge is made by copying on a sensitive plate a circular gelatin wedge (see Fig. 5). To

facilitate turning, the wedge projects $1/8$ inch from under the instrument cover.

The beam of light after passing through the wedge falls upon the opal glass *H*. The photographic image to be measured is laid on this diffusing screen. The opal glass also acts as an illuminator for the detection of the spot to be measured.

A second beam of light coming from the lamp is led around by the two mirrors *B* and *D* to the photometric head. This head consists

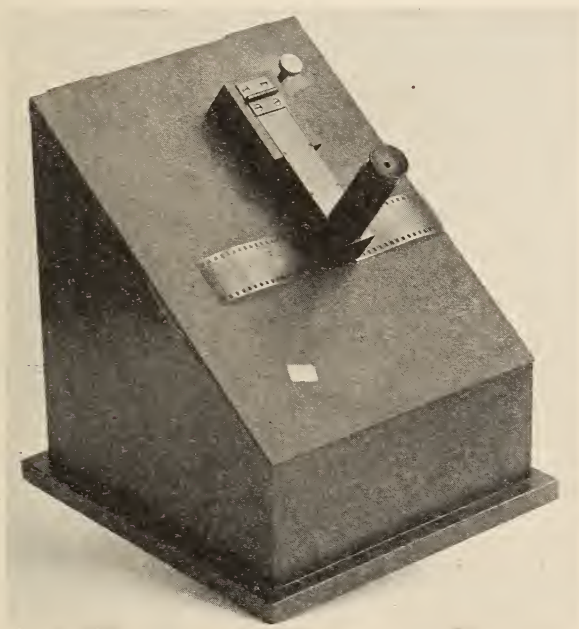


FIG. 2. General view of densitometer.

of a plane glass *F* set at an angle of 45 degrees, so arranged that the light from the mirror system is reflected to the base of the head. The two surfaces of the plane glass reflect sufficient light (about 10%) to furnish the comparison beam. In order to insure a uniform patch of light, a piece of opal glass *C* is placed between the mirror *B* and *D* and a piece of ground glass *E* between *D* and *F*. In the base is a circular piece of plane silver mirror *G* with its silver side nearest the opal glass *H*. In the center of the mirror the silver is removed over an area of $1/2$ mm. in diameter.

The observer sees in the eyepiece *J* a spot illuminated by the opal *H* surrounded by a comparison field illuminated from the mirrors *B*, *D*, and *F*. The eyepiece contains a suitable magnifier.

In order to make the dividing line in the photometric field become entirely invisible when the two parts of the field are balanced, the mirror *G* is thinly silvered and thinly varnished. The silver is removed from the center of the mirror by covering the silver side with a template having a hole of the desired area ($1/2$ sq. mm.) and scratching away the silver with a brass needle. The silver surface is protected from the atmosphere and from scratching by cementing

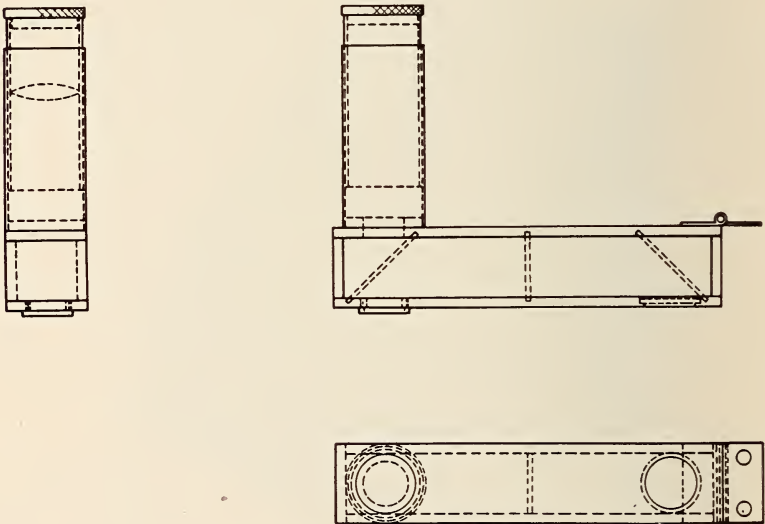


FIG. 3. Plan of mirror tunnel.

with Canada Balsam a micro-cover glass onto the mirror. In order to prevent scattered light from entering the photometric field when a small dense spot is surrounded by a large light area, and also to act as a bumper, a thin sheet of dull black paper is pasted over the cover glass.

In the center of the black paper a hole is cut slightly larger than the hole in the silver surface of the mirror. As the density to be measured is never in perfect optical contact with the mirror, the size of this hole is a factor in determining the minimum size of the spot which can be measured.

The instrument was calibrated by carefully measuring on the Capstaff-Green densitometer the densities of a series of neutral gray gelatin films. After finding with each of these densities the position of the wedge which enables the field to be balanced, the values were marked on the wedge itself, a suitable window being provided on the top of the instrument case.

The measured films increased in density by 0.1; the intermediate graduation divisions were interpolated. As the wedge throughout the greater part of its length increased uniformly in density, the graduation divisions were consequently uniform over this range. The need for extreme care in the calibration of the wedge should be

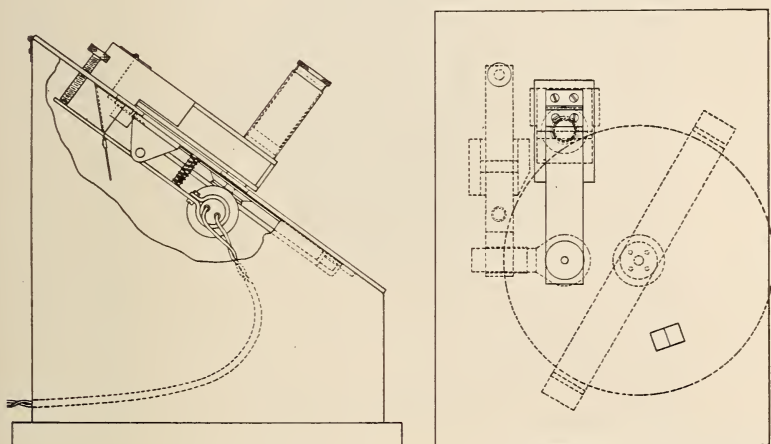


FIG. 4. Sectional view of densitometer.

emphasized, as it is essentially the element upon which the precision of the instrument depends.

To make measurements; the photometric balance is first adjusted at the zero position by slightly moving the lamp to or fro by means of the thumb screw *K*. After once determining the zero position, it is only rarely that the lamp distance needs to be altered. The density to be measured is then placed in contact with the opal, and the photometric balance is re-established by rotating the wedge.

The performance of the instrument was tested by measuring a number of uniform densities separately and then in pairs. It was found that the superimposed pairs agree within 0.02 of the arithmetical sum of the single densities. Similar agreement was found when three pairs of densities were superimposed. A further test was

made by exposing a photographic plate under these neutral dye densities and giving exposures through the various pieces as indicated by the measured values, so that the developed plate would have a uniform density if the measurements were correct. Several trials were made, and in each case it was found that the measured density corresponded to within 0.02 of the printing density.

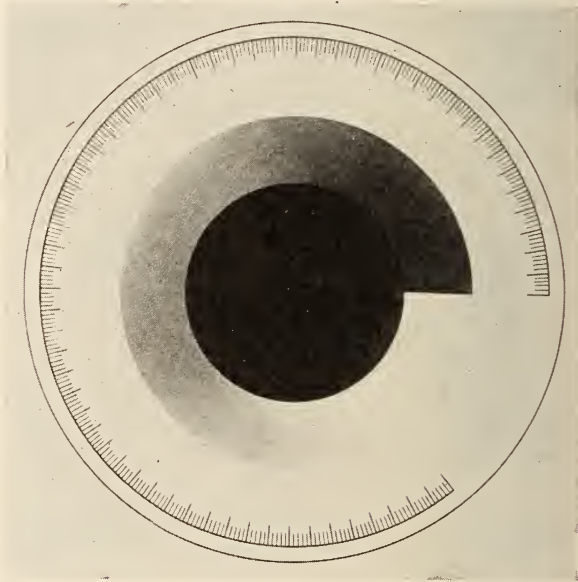


FIG. 5. The circular wedge.

It is obvious, of course, that the densitometer is not limited to measuring the densities of motion picture images; it can be used for other work in photography where transmission factors are desired. This instrument has been used for two years in this laboratory and has proved satisfactory for the purpose for which it was constructed.

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MEETING OF SEPTEMBER 26, 27, 28, 29, 1927

LAKE PLACID, N. Y.

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 Cooper-Hewitt Electric Co., 410 8th St., Hoboken, N. J.
- CAMPE, H. A. (M).**
 Westinghouse Electric & Mfg. Co., 5550 Raleigh St., Pittsburgh, Pa.
- CAPSTAFF, JOHN G. (M).**
 Eastman Kodak Co., Kodak Park, Rochester, N. Y.

- CARPENTER, ARTHUR W. (A).
Carpenter-Goldman Lab., 161 Harris Ave., Long Island City, N. Y.
- CAVALIERE, NICHOLAS (A).
38 Mechanic St., New Haven, Conn.
- CHANIER, G. L. (M).
Pathé Exchange, 1 Congress St., Jersey City, N. J.
- CIFRE, J. S. (M).
Nat. Theater Supply Co., 211 Columbus Ave., Boston, Mass.
- CLARK, CHAS. H. (M).
60 Grand St., New York, N. Y.
- CLARK, JAMES L. (M).
Akeley Camera Inc., 175 Varick St., New York, N. Y.
- CLARKE, ERIC T. (A).
Eastman Theater, Rochester, N. Y.
- COFFMAN, JOE W. (A).
710 St. Nicholas Ave., New York, N. Y.
- COHEN, EMMANUEL (M).
145 West 55th St., New York, N. Y.
- COHEN, JOSEPH H. (M).
Atlantic Gelatine Co., Hill St. Woburn, Mass.
- CONKLIN, ROBERT (A).
S. Mountain Road, New City, Rockland Co., N. Y.
- COOK, OTTO W. (M).
Research Lab., Eastman Kodak Co., Kodak Park, Rochester, N. Y.
- COOK, WILLARD B. (M).
Kodascope Libraries, Inc., 35 West 42nd St., New York, N. Y.
- COWLING, HERFORD T. (M).
Eastman Kodak Co., 343 State St., Rochester, N. Y.
- COZZENS, LOUIS S. (M).
Du-Pont-Pathé Film Mfg. Co., Parlin, N. J.
- CRABTREE, JOHN I. (M).
Eastman Kodak Co., Kodak Park, Rochester, N. Y.
- CUFFE, LESTER E. (A).
DeMille Studios, Culver City, Calif.
- CUMMINGS, JOHN S. (A).
Cummings Laboratory, 23 West 60th St., New York, N. Y.
- CURLE, CHAS. E. (A).
1902 East 12th St., Chattanooga, Tenn.
- DANASHEW, ANATOLE W. (A).
Government Motion Pictures, Prechistenka, Obulkov per No. 6, Apt. 8, Moscow, Russia.
- DASH, CYRUS C. (M).
Hertner Electric Co., 1905 W. 114th St., Cleveland, Ohio.
- DAVIDSON, L. E. (A).
Visual Demonstration System Inc., 259 Delaware Ave., Buffalo, N. Y.
- DEFORREST, LEE (M).
DeForest Phonofilm, Inc., 318 E. 48th St., New York, N. Y.
- DENISON, EARL J. (M).
Sentry Safety Device Co., 1560 Broadway, New York, N. Y.
- DEPUE, OSCAR B. (A).
DePue and Vance, 7512 N. Ashland Ave., Chicago, Ill.
- DE VAULT, RALPH P. (M).
Acme Motion Picture Projector Co., 1134 W. Austin Ave., Chicago, Ill.
- DE WITT, H. N. (A).
Patheoscope Co. of Canada Ltd., 156 King St. W., Toronto, Ontario, Canada.
- DOWNES, A. C. (M).
National Carbon Co., Carbon Development Laboratory, Cleveland, Ohio.
- DUNBAUGH, GEO. J., Jr. (A).
Champion Mfg. Co., 7332 Kimball Ave., Chicago, Ill.
- DUNNING, CARROLL D. (A).
F.B.O. Studios, Gower St., Hollywood, Calif.
- EDWARDS, GEORGE C. (A).
American Projectionist, 101-21 Seventy Eighth St., Ozone Park., Long Island, N. Y.
- EGELER, CARL E. (M).
National Lamp Works, Engineering Dept., Nela Park, Cleveland, Ohio.
- EMSLIE, EMMETT K. (A).
Buick Motor Co., Factory No. 17, Flint, Mich.
- FAULKNER, TREVOR (A).
Famous Players-Lasky Corp., Film Dept. 6th & Pierce Aves., Long Island City, N. Y.
- FERNANDEZ, CECIL (A).
Trumbull Amusement Co. of St. Petersburg, P. O. Box 7305, West Tampa, Fla.
- FLEISCHMANN, LEON (M).
Loew, Inc., 1540 Broadway, New York, N. Y.
- FLICKINGER, EDWARD (A).
Ford Motor Co., of Canada. 204 Maple St., Windsor, Ontario, Canada.
- FLYNN, KIRTLAND (M).
Celluloid Co. of Newark, 290 Ferry St., Newark, N. J.

- FRITTS, EDWIN C. (M).
Eastman Kodak Co., 343 State
Street, Rochester, N. Y.
- FULCHER, EDGAR J. (A).
157 Albert Street East, Saulte Ste.
Marie, Ontario, Canada.
- FULTON, C. H. (A).
c/o E. F. Fulton Co., 1018 South
Wabash Ave., Chicago, Ill.
- GAGE, HENRY P. (M).
Corning Glass Works, Corning, N. Y.
- GAGE, OTIS A. (A).
Corning Glass Works, Corning, N. Y.
- GAUMONT, LEON (M).
Gaumont Co., 57 Rue Saint Roch,
Paris, France.
- GEIB, E. R. (A).
National Carbon Co., Box 400,
Cleveland, Ohio.
- GELMAN, J. N. (M).
3439 Jay St., Cincinnati, Ohio.
- GERRARD, WM. C. (A).
3212 54th St., Woodside, Long
Island, N. Y.
- GOLDMAN, LYLE F. (A).
Carpenter-Goldman Lab., 161 Harris
Ave., Long Island City, N. Y.
- GORDON, IRL (A).
Orpheum Theater, Akron, Ohio.
- GRAY, ARTHUR H. (A).
Lancaster Theater, Lancaster &
Causeway Sts., Boston, Mass.
- GREENE, CHAUNCEY L. (A).
3141 Harriett Ave. S., Minneapolis,
Minn.
- GREGORY, CARL LOUIS (M).
76 Echo Ave., New Rochelle, N. Y.
- GRIFFIN, HERBERT (M).
International Projector Corp., 90
Gold St., New York, N. Y.
- HALVERSON, C. A. B. (M).
General Electric Co., West Lynn,
Mass.
- HAMISTER, VICTOR C. (M).
National Carbon Co., W. 117th &
Madison Ave., Cleveland, Ohio.
- HANDSCHIEGL, MAX (M).
1040 McCadden Place, Los Angeles,
Calif.
- HANNA, CLINTON R. (A).
Westinghouse Elec. & Mfg. Co.,
Research Dept., E. Pittsburgh,
Pa.
- HANSEN, E. H. (M).
Fox-Case Corp., 54th St. at 10th Ave.,
New York, N. Y.
- HARRINGTON, THOMAS T. (M).
2242 Grove St., Berkeley, Calif.
- HEDWIG, WILLIAM, K. (M).
W. K. Hedwig M. P. Enterprises,
Inc., Park Pl. & Congress Ave.,
Flushing, Long Island, N. Y.
- HENNESSY, WILLIAM W. (A).
Eastman Theater, Rochester, N. Y.
- HIBBERD, FRANK H. (M).
Duplex Motion Picture Industries,
Harris Ave. & Sherman St., Long
Island, N. Y.
- HICKMAN, KENNETH (M).
Eastman Kodak Co., Kodak Park,
Rochester, N. Y.
- HILL, ROGER M. (M).
793 Williams St., Atlanta, Ga.
- HOLMAN, ARTHUR J. (M).
56 Cummings Rd., Brookline, Mass.
- HORNIDGE, HENRY T. (A).
Kiddle & Margeson, 115 Broadway,
New York, N. Y.
- HORNSTEIN, J. C. (A).
National Theater Supply Co., 1560
Broadway, New York, N. Y.
- HOWELL, A. S. (M).
Bell & Howell Co., 1801 Larchmont
Ave., Chicago, Ill.
- HOWELL, JOHN F. (M).
Akeley Camera Inc., 175 Varick St.,
New York, N. Y.
- HUBBARD, ROSCOE C. (M).
Consolidated Film Industries, 203
West 146th St., New York, N. Y.
- HUBBARD, WM. C. (M).
Copper-Hewitt Electric Co., 410
8th St., Hoboken, N. J., Mail to
111 W. 5th St., Plainfield, N. J.
- HUESGEN, CHARLES K. (A).
Herbert & Huesgen, 18 East 42nd
St., New York, N. Y.
- HUMPHREY, GLENN H. (A).
The Aderaft Film Service, 132
Genesee St., Utica, N. Y.
- ISAAC, LESTER B. (A).
Marcus Loew, Inc., 1540 Broadway,
New York, N. Y.
- IVES, F. E. (M).
1808 N. Park Ave., Philadelphia, Pa.
- JEFFREY, FREDERICK A. (A).
9 Giles St., Toorak, Adelaide, South
Australia.
- JENKINS, FRANCIS C. (Honorary)
5502 16th St., Washington, D. C.
- JOHN, ROBERT (M).
West End Plaza and West End Ave.,
Long Branch, N. J.
- JOHNSTONE, W. W. (A).
Bausch & Lomb Optical Co., 28
Geary St., San Francisco, Calif.

- JONES, JOHN G. (M).
Eastman Kodak Co., Kodak Park,
Rochester, N. Y.
- JONES, JOHN M., Jr. (A).
435 Beaumont Ave., Charlotte, N. C.
- JONES, L. A. (M).
Eastman Kodak Co., Kodak Park,
Rochester, N. Y.
- JOY, JOHN M. (M).
Fox Film Corp., 850 Tenth Ave.,
New York, N. Y.
- KELLEY, WM. V. D. (M).
Kelley Color Films Inc., 1040
McCadden Place, Hollywood,
Calif.
- KEUFFEL, CARL W. (A).
Keuffel-Esser Co., 3rd & Adams St.,
Hoboken, N. J.
- KILBORN, ORSON (A).
Peroff Pictures, Inc., 67 West 44th
St., New York, N. Y.
- KROESEN, J. C. (M).
Edison Lamp Works, Harrison, N. J.
- KUNZMANN, WM. C. (M).
Suite 2-2992 West 14th St., Cleve-
land, Ohio.
- KURLANDER, JOHN H. (M).
Brenkert Light Projection Co., 7348
St. Aubin Ave., Detroit, Mich.
- LAIR, C. (M).
Pathé Cinéma 30 Rue des Vignerons,
Vincennes, France.
- LANG, C. J. (M).
Lang Mfg. Works, Olean, N. Y.
- LA RUE, MERVIN W. (A).
5255 North Hoyne Ave., Chicago, Ill.
- LAWTON, FRANCIS, JR. (A).
Jam Handy Picture Service, 420
Lexington Ave., New York, N. Y.
- LEVENTHAL, J. F. (M).
c/o E. Schlegel, 125 E. 23rd St.,
New York, N. Y.
- LEWIS, WILLIAM W. (A).
J. E. McAuley Mfg. Co., 554 West
Adams St., Chicago, Ill.
- LITTLE, W. F. (M).
Electrical Testing Lab., 80th St. &
East End Ave., New York, N. Y.
- MACGREGOR, CHARLES D. (A).
Griffin Opera House, King Street
West, Chatham, Ontario, Canada.
- MACKENZIE, DONALD (M).
Bell Telephone Labs., Inc., 463 West
St., New York, N. Y.
- MACLEOD, J. S. (M).
Metro-Goldwyn-Mayer Pictures, 1540
Broadway, New York, N. Y.
- MACAULEY, J. E. (M).
McAuley Mfg. Co., 552 W. Adams
St., Chicago, Ill.
- MCCLINTOCK, NORMAN (A).
504 Amberson Ave., Pittsburgh,
Pennsylvania.
- MCGINNIS, F. J. (A).
Box 2387, West Palm Beach, Fla.
- MCGUIRE, PERCIVAL A. (M).
International Projector Corp., 90
Gold Street, New York, N. Y.
- M McNABB, J. H. (M).
Bell & Howell Co., 1801 Larchmont,
Ave., Chicago, Ill.
- MAIRE, HENRY J. (A).
2152 Center Ave., Fort Lee, N. J.
- MANHEIMER, J. R. (M).
E. J. Electric Installation Co., 155
East 44th St., New York, N. Y.
- MATHER, GEORGE E. (M).
Bell Telephone Labs., 463 West St.,
New York, N. Y.
- MATLACK, CLAUDE C. (A).
Matlack Corp., 323-23rd Street,
Miami Beach, Fla.
- MAYER, MAX (M).
233 West 42nd St., New York, N. Y.
- MECHAU, EMIL (A).
E. Leitz Inc., Rastatt, Germany.
- MEES, C. E. K. (M).
Eastman Kodak Co., Kodak Park,
Rochester, N. Y.
- MILLER, ARTHUR P. (A).
Chicago Film Laboratory 1322 Bel-
mont Ave., Chicago, Ill.
- MISTRY, D. L. (A).
24 Nepean Rd., Malabar Hill, Bom-
bay 6, India.
- MISTRY, M. L. (A).
24 Nepean Rd., Malabar Hill,
Bombay 6, India.
- MITCHELL, GEO. A. (M).
Mitchell Camera Co., 6025 Santa
Monica Blvd., Los Angeles, Calif.
- MITCHELL, R. FAWN (A).
5729 Ridge Ave., Chicago, Ill.
- MOLONEY, FRED G. (M).
Helios Corp., 7544 S. Chicago Ave.
Chicago, Ill.
- MORENO, R. M. (A).
DuPont Pathe Film Mfg. Corp.,
Parlin, N. J.
- MORTON, H. S. (A).
Adams Theater, Detroit, Mich.
- MURRAY, WM. W. (A).
528 Madison Ave., Scranton, Pa.
- NELSON, OTTO (M).
National Cash Register Co., Dayton,
Ohio.
- NIXON, IVAN L. (M).
Bausch & Lomb Optical Co., Ro-
chester, N. Y.

- NORLING, J. A. (A).
Loucks & Norling Inc., 723 Seventh Ave., New York, N. Y.
- NORRISH, B. E. (M).
Associated Screen News, Western Ave. & Delcarie Blvd., Montreal, Canada.
- O'BRIEN, MORTON D. (A).
Marcus Loew Inc., 1540 Broadway, New York, N. Y.
- OLSON, E. B. (A).
Warner Bros. Theater, Hollywood, Calif.
- OWENS, FREEMAN H. (A).
70 Lafayette St., New York, N. Y.
- PALMER, M. W. (M).
Famous Players-Lasky Corp., 6th & Pierce Aves., Long Island City, N. Y.
- PATON, GEORGE E. (A).
Province of Ontario Pictures, 46 Richmond St. West, Toronto, Ontario, Canada.
- PENNOW, WILLIS A. (A).
Perfection Arc Co., 14th St., and North Ave., Milwaukee, Wis.
- PENROD, A. G. (A).
Bristol Co., Waterbury, Conn.
- PEYTON, JOHN T. (A).
623 West Wheeler St., Oklahoma City, Okla.
- PHELPS, L. G. (M).
818 Chapel St., New Haven, Conn.
- PHILLIMORE, CHAS. E. (A).
Q. R. S. Music Co., 306 So. Wabash Ave., Chicago, Ill.
- PLANSKOY, LEONTI (M).
Riviera Studios, Harry Lachman Productions, Inc. St. Andrè de Nice, France.
- POMEROY, ROY J. (M).
Famous Players-Lasky Corp., 5451 Marathon St., Hollywood, Calif.
- PORTER, L. C. (M).
Edison Lamp Works, Harrison, N. J.
- POSEY, O. D. (M).
Southern Enterprise Inc., 58½ Cone St., Atlanta, Ga.
- POWRIE, JOHN H. (M).
Warner Research Lab., 461 Eighth Ave., New York, N. Y.
- PRACHETT, A. B. (A).
Caribbean Film Co., Estrada Palma 112, Havana, Cuba.
- PRICE, HICKMAN (A).
Fox Film Corp., 850 Tenth Ave., New York, N. Y.
- PUFFER, B. FRANK (M).
Eureka Film Corp., 921 Provident Bank Bldg., Cincinnati, Ohio.
- QUINLAN, WALTER (M).
Fox Film Corp., 850 Tenth Ave., New York, N. Y.
- RAESS, HENRY F. (A).
Warner Research Lab., 461 Eighth Ave., New York, N. Y.
- RAVEN, A. L. (M).
Raven Screen Co., 1476 Broadway, New York, N. Y.
- RAYTON, WM. B. (M).
Bausch & Lomb Optical Co., Rochester, N. Y.
- REDPATH, WM. (M).
156 King St. W., Toronto, Canada.
- REICH, CARL J. (M).
Gundlach-Manhattan Optical Co., 739 Clinton Ave., Rochester, N. Y.
- RENWICK, F. F. (A).
Ilford, Ltd., Ilford, Essex, England.
- RICHARDSON, FRANK H. (M).
Moving Picture World, 516 Fifth Ave., New York, N. Y.
- ROBINSON, KARL D. (A).
2 West 16th St., New York, N. Y.
- ROBINSON, L. T. (M).
General Electric Co., Schenectady, N. Y.
- ROGERS, ROWLAND (A).
Picture Service Corp., 71 West 23rd St., New York, N. Y.
- ROMELL, F. J. (A).
Romell Motion Pictures, Inc., 908 Schmidt Bldg., Cincinnati, Ohio.
- ROSENBERGER, HEINZ (A).
Rockefeller Institute, 66th St. & Avenue A, New York, N. Y.
- ROSS, OSCAR A. (M).
Room 907, 79 West 45th St., New York, N. Y.
- ROSSMAN, EARL W. (M).
City Club of New York, 55 West 44th St., New York, N. Y.
- RUBEN, MAX (A).
2647 W. Philadelphia Ave., Detroit, Mich.
- RUBIN, HARRY (A).
Rialto Theater, Broadway & 42nd St., New York, N. Y.
- RUDOLPH, WM. F. (A).
Famous Players-Lasky Studio, 1546 Argyle St., Los Angeles, Calif.
- RUOT, MARCEL (A).
Pathé of France Ltd., 5 Lisle Street, London, W. I., England.
- SAMUELS, IRVING (A).
Automatic Devices Co., Hunsicker Bldg., Allentown, Pa.
- SAVAGE, F. M. (A).
3 Potter Place, Weehawken, N. J.

- SCHMITZ, ERNEST C. (A).
Kodak Co., Ciné Dept., 39 Avenue
Montaigne, Paris, France.
- SEASE, VIRGIL B. (M).
Du Pont-Pathé Film Mfg. Co., Par-
lin, N. J.
- SENNER, ADOLPH G. (A).
Herbert & Huesgen Co., 18 East
42nd St., New York, N. Y.
- SERRURIER, IWAN S. (M).
1123 No. Bronson Ave., Hollywood,
Calif.
- SHACKELFORD, J. B. (A).
6620 St. Francis Court, Hollywood,
Calif.
- SHEPPARD, SAMUEL E. (M).
Eastman Kodak Co., Kodak Park,
Rochester, N. Y.
- SHIMEK, JOHN A. (A).
DeVry Corp., 1111 Center St.,
Chicago, Ill.
- SISTROM, WILLIAM (M).
Cecil B. DeMille Studio. Culver
City, California.
- SKALL, WILLIAM V. (M).
Eastman Kodak Co., 343 State St.,
Rochester, N. Y.
- SLOMAN, CHERI M. (A).
3008 Lakewood, Detroit, Mich.
- SPENCE, JOHN L. (M).
175 Varick St., New York, N. Y.
- SPONABLE, EARL I. (M).
277 Park Ave., Apt. 2, W. New York,
N. Y.
- SPRUNCK, PAUL G. (M).
DeMille Studio, Culver City, Calif.
- STEWART, VICTOR A. (M).
411 West End Ave., New York,
N. Y.
- STORTY, FRANK J. (A).
Loew's Palace Theater, 1306 F St.,
N. W., Washington, D. C.
- STRUBLE, CORNELIUS D. (A).
National Theater Supply Co., 624
So. Michigan Ave., Chicago, Ill.
- SUMMERS, JOHN A. (M).
Edison Lamp Works, Harrison, N. J.
- SWAAB, MARK L. (A).
L. M. Swaab & Son, 1325 Vine St.,
Philadelphia, Pa.
- TAMLIN, B. G. (A).
Jeffery Laboratory, 9 Giles St., Rose
Park, S. Australia.
- TAYLOR, JOHN B. (M).
General Electric Co., Schenectady,
N. Y.
- THEISS, JOHN H. (M).
E. I. Du Pont De Nemours, 35 W.
45th St., New York, N. Y.
- TOPLIFF, GEO. W. (A).
Anseo Co., Binghamton, N. Y.
- TOWNSEND, LEWIS M. (M).
Eastman Theater, Rochester, N. Y.
- VICTOR, A. F. (M).
Victor Animatograph Co., 242 W.
55th St., New York, N. Y.
- VINTEN, WM. C. (M).
89 Wardour St., London W. I., Eng-
land.
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Cecil B. De Mille Studio, Culver
City, Calif.
- WALL, EDWARD J. (M).
38 Bromfield St., Wollaston, Mass.
- WALLER, FRED (M).
R. F. D. No. 3, Huntington, Long
Island, N. Y.
- WARD, G. BERT (M).
Super Laboratories, Palisade Junc-
tion., N. J.
- WATSON, JAMES S., JR. (A).
11 Prince St., Rochester, N. Y.
- WILLIAMSON, COLIN M. (A).
Williamson Manufacturing Co. Ltd.,
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- WOOSTER, JULIAN S. (A).
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FRAMING THE PROJECTED PICTURE WITH COLORED BORDERS

LEWIS M. TOWNSEND*

FROM time to time during the past twenty years, the idea of using colored borders to frame the projected motion picture has been brought forth. This has been advocated by several different people and has had as many different reasons presented for its use. One of the first was that daylight projection could be obtained in this manner. The promoters of this idea claimed that when projecting a border they were at the same time projecting a shadow on the screen which the theater lights could not penetrate, because the theater lights were less brilliant than the beam of projected border light. In reality the only reason this system lasted as long as it did was that the men who installed it were just a little better educated in the problems of projection than the average. For this reason they were able in most cases to raise the illumination of the projected picture far enough above the average that had been used in that particular theater, so that more house lights could be used without blotting out the picture. This system was quite popular in many of our combination vaudeville and picture theaters about 1909-1910. The fallacy of this idea was quickly proved, as knowledge of projection became more widely distributed and as equipment was improved, so as to permit of better illuminated pictures. The above system was usually accomplished by using a metal cut-out slide because considerable trouble was encountered by the slides cracking if made of glass. From time to time since then, many people have practised projecting colored or elaborately designed borders around the pictures. Some claimed that it relieved eye strain, while others, who I believe were a trifle more conscientious, claimed that it was merely for decoration and to give a pleasing result to the audiences.

One system was used for some time at the Capitol Theater in New York. This apparatus consisted of a double stereopticon, each

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part of which was equipped with a double head. To each head was delivered one-half the light of the arc by means of a ruled mirror. With this arrangement it was possible to project four different colored slides at the same time. Part of a design would be on one slide and part on another. The resulting border was a very elaborately designed affair in four colors. The slides were smaller than standard. An objective of the same focal length was used as in the motion picture projectors, thus making the opaque spot the same size as the aperture of the projectors. Compressed air blowers were used to play on the slides during operation to keep them from cracking. A system of this kind was of course out of the question for the average theater. We tried this same system with variations.

In the meantime the Quartz slides had been developed. This eliminated the blowers, but of course the slides were expensive. The slides were made by the wet plate process. They were absolutely black and white with no gradations or half tones. At first it was proposed to take the light from the arc which supplied the illumination for the projection of motion pictures. This was to be done by a system of mirrors, the reason being that in this way there would be no added expense to the theater after the apparatus was installed. This would have made the system available to the small theater as well as the large. On account of the multiplicity of light sources now in use, however, this part of the idea was discarded and a straight light source was used. The source decided upon was a 1,000 watt, 110 volt, mazda bulb. Some of the results were very good, but what we wanted was a means of projecting shades of gray as well as black and white in order to give gradation and tone to the colors which were introduced. After giving this system a thorough trial, it was discarded because it was felt that better results could be had by the use of a slide of larger rather than of smaller dimensions than the standard lantern slide. Inasmuch as I already had available large stereopticons with 8" diameter condensers which would accommodate a standard 5×7 plate, I decided to try this larger size. At first I believed it necessary to use something other than glass because of breakage. I later discovered however, that glass plates can be projected with this machine as long as is desired without cracking provided a little care is used. At present I am using two 19 inch focus, 8 inch diameter condensers and an 18 inch focus objective to project a 5×7 slide the mat of which is 4 inches×6½ inches. I am using a ¾ inch×12 inches AC lower carbon as a positive and a ⅝" copper coated negative.

The current applied is 75 amperes, the distance is 160 feet, the image is approximately 24 feet \times 36 feet and the illumination is very good. It would be impossible to cover this area with an ordinary lantern slide without applying far too much current for the slide to stand without cracking in a very seconds. I have projected a 5 \times 7 plate or slide as long as 30 minutes without cracking it. In fact, I have never had one crack because of heat.

So much for the process. How can it be used? What are the objectionable features? Are there any good features? After various trials we have found that, if a border is projected around the picture, it must be quite free of any complicated design. In fact very little design if any can be used successfully for the reason that it is very likely to detract from the picture. Another thing to avoid is excessive brightness. We have found that at no time should the total brightness of the border exceed more than one-half the intensity of the screen image. In the majority of cases this should not be more than one-quarter as bright.

The next important item is the proper and harmonious application of color. In general, brilliant colors should not be used. It should be remembered at all times that the border must be subordinated to the picture. This should be done by keeping the color of the border darker than the tint of the film, if any, and by keeping the intensity considerably below that of the picture. We have found, that in very rare cases, if any, is it advisable to use a border during the whole presentation of a feature picture. In the first place, the tints in most pictures change so often from scene to scene, and in many cases such as cut-backs the scenes are of such short duration that it is practically impossible to make the changes that should be made to keep the border in any kind of harmony with the screen image. We have found, however, that a colored border can be used during certain scenes and to very good advantage, for example, such as using a red border during fire scenes, blue during flood scenes, and so forth. We have made the best use of the projected border on short subjects in the following ways:

1. Black and white scenic films. A waterfall or woodland scene, for instance is tinted green by placing a good photographic filter in front of the objective lens—that is by flooding the whole screen and stage opening with dark blue and then projecting a graduated border of green from the edge of the picture to the edge of the stage opening. This gives a color combination that is both pleasing and in good

harmony of blue, blue-green, and green. This could be varied somewhat by projecting a very dark green flood to cover just the motion picture screen and tinting the film yellow.

2. Tinted and toned subjects. In this instance we shall take a scenic whose image is toned blue and has tinted highlights. It is quite natural to use a dark blue and magenta border. This is subdued in comparison to the screen image in both intensity and hue and produces good color and harmony. If more contrast is desired, it would be quite possible to use an orange and blue border and still have pleasing results.

3. When tinted subjects are used in which the colors are changed with the different scenes, it is necessary to change the border with the change of scene color or else choose a color that will be in keeping with the majority of scenes.

4. We have found also that cartoons which are usually of yellow or amber tint can be made more enjoyable by giving them a border of orange and red of fairly high intensity and arranging the mask so that the orange is carried down to flood the orchestra at the same time.

5. The same holds true of song films, and in this case we often add a spot to cover the singer at the side. When this is done along with the border, it is much more pleasing than just projected reading matter and a singer standing off to the side in a strong white spot outlined by absolute darkness.

You will note that in the above I have pleaded for color harmony in connection with the projected borders. This does not mean that we cannot have contrasting and striking effects, but I do want to put across the idea that projected borders made with a very elaborate design and projected with too many strong, contrasting colors are likely to jar rather than to please.

DISCUSSION

MR. RICHARDSON: At the time that the "Capitol" installation was being arranged I was called in by Mr. Martin, who was responsible for it. He asked me to go over to Jersey City and witness a demonstration of the bordered picture. I liked the effect, but I was unable to explain why the perspective was very much better when the border was put on.

MR. TOWNSEND: There are certain color combinations that will give the projected picture an apparent depth. That is one reason I

haven't gone further with this paper. I thought it better to stop where I have and get the views of other people for further data.

MR. KURLANDER: I should like to support what Mr. Richardson said. At the time Mr. Martin was experimenting with this, Mr. Joy of the Motion Picture Producers called me in to see it, and I was struck by the fact that it had increased depth, and it didn't matter what the design or color was, although it seemed to detract from the action within the picture.

MR. CUFFE: I might say in regard to the illusion of depth that the producers of "Wings" are experimenting on this.

A FEW PRACTICAL NEEDS IN THE FIELD OF PROJECTION

ARTHUR H. GRAY*

SOME of the present day major problems of the projectionist and the needs for improvement in certain phases of projection practice are not new problems or new needs. That they are not new, however, should make them of no less concern to us, so long as they continue to exist, than should new developments of no greater import.

Whether of recent origin or otherwise it will be the purpose of this paper to set forth, from the viewpoint of the practical projectionist, several of the more important problems which he believes should be given attention by those who are in a position to apply the necessary remedies.

Some of our projection problems, or let us call them projection conditions, are due simply to errors in business judgment. They are not technical or complicated problems and, in themselves, are easily understood. The difficulty is in understanding why they have been remedied to no greater extent than has been the case.

Projection conditions are not alike in all theaters nor in all classes of theaters. At one end of the scale we have the large, deluxe type of show house which usually uses nothing but new, first-run film. At the other extreme is the small, village picture hall which cannot afford new film and often gets its film only when it has been used by nearly everyone else.

These extreme types of theaters have many distinct problems of their own and may be exempt from many problems experienced by the majority of theaters which constitute the largest field and in which the projection conditions are more or less common to all. It is with the difficulties of the many that we will chiefly concern ourselves.

General Condition of Circulating Film is Improving

The general condition of circulating film, judged from a standard of screen appearance as well as by its ability to pass through a projector without suffering mishap, seems to be improving gradually. An

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increasing number of exhibitors have been educated to the fact that a scratched, dirty print seriously impairs the entertainment value of the picture and are insisting on receiving film in better condition. Also, the exchanges have more or less awakened to the economic loss which results from improper handling and care of film. The distributors seem to be giving this matter considerable attention, and an interesting paper was presented at our Washington meeting showing the nature of survey work being done in this connection.¹ As a result of this education, some exchanges have greatly improved their methods of inspecting and repairing film, and much good has resulted.

On the other hand, other exchanges persist in practicing lax methods. From the condition into which some of the exchanges allow some of their prints to deteriorate within a short period, it would appear they had no appreciation at all of the value of their own property or no sense of obligation in the matter of providing the exhibitor with clean, undamaged prints. Though substantial progress may be generally noted, the need for eliminating much unnecessary damage to film continues to exist.

Need for Greater Care in Handling of Film

The part of the film where damage and wear might be expected to develop first is the perforations, but this does not seem to be the common case. Some damage of this nature does of course exist, but unless the film has been abused in the projector—and then probably during the first time it was projected—most perforations do not show any unusual wear until the print has had considerable use.

The common damage which begins to develop early and continues to accumulate during the life of the print is in the nature of scratches, oil, dirt, poor splices, and things of like nature. Some of this is due to normal wear in the projector, but much of it is unnecessary and is caused by careless handling of the film. It may occur while being projected or rewound in the projection room. It is likely to happen at the exchange, from the manner in which I have seen it thrown around in some shipping rooms, and through hurried handling by some of the girls in the inspection room. It also frequently occurs during shipment to the theater. It is not a rare occurrence for a theater to receive film which is in a tangled mass in the shipping case, because the reel or reels upon which the film had been wound had come completely apart.

¹ Film Mutilation by J. M. Joy, Trans. S.M.P.E. No. 26, p. 5 (1926).

Poor Shipping Reels Cause Damage to Film

A large amount of damage is caused by poor reels. Apparently it has been a problem of exchanges to obtain a good substantial, improved type of shipping reel; otherwise, there seems no excuse for continuing to ship out film upon the flimsy, cheaply made, sheet metal reels which have been used for many years.

Film is often received wound upon reels that have badly burred edges, dented and warped flanges, flattened hubs, and faults of like nature. These reels are utterly unfit for even the temporary purpose to which they are put. It is impossible to wind film on or off some of these reels without damaging the print, and much damage does occur in this way. This apparent lack of interest in the care of their own film sets a rather poor example to the projectionist, especially when there may be a nicely worded appeal to him pasted under the cover of the shipping case to co-operate with the exchange in the matter of eliminating damage to film.

It is difficult to understand why exchanges have not developed a suitable reel themselves if unable to obtain them on the market. I am of the opinion that good reels are available. They would probably cost more to buy but in the long run should prove less expensive because they would have a longer life. In any event, and from the viewpoint which is most important, they would aid materially to reduce the present amount of preventable film damage.

Exchange Inspection does not Remove all Poor Splices

Despite the improved methods of inspecting film at the exchanges, and the repairs which are made prior to shipment, it is the general experience of projectionists with whom I have discussed the matter that the print invariably must be re-examined at the theater before being projected if a reasonable assurance against the film breaking while in the projector is to be had. They have learned that, while most of the loose splices are detected and removed at the exchange, some of them are not, and it requires only a single splice separating while in the projector to stop the show. The competent projectionist classifies this kind of accident as just about the worst possible thing which can happen in his work, and yet despite all the routine precautions which are taken to prevent it, mishaps of this nature continue to occur.

There are so many splices in some prints, especially those with numerous color inserts, that not all of them receive the frequent atten-

tion which is necessary to detect the first signs of them loosening up, and when once a splice has started to loosen, it is a menace until re-made. The fewer splices there are in a print, the less probable cause for trouble there will be; and, in making up prints, any planning which will keep the necessary number of splices at the minimum is desirable.

Many Laboratory Splices are Improperly Made

It is my own experience and, I think, the general one among projectionists that the kind of loose splice which gives the most trouble is the machine-made, laboratory splice. In our projection room at the Lancaster Theater, a record is kept of the amount and kind of repair work necessary to the film which we project, and some of this data may be of interest.

*Lancaster Theater Projection Room Film Inspection Record For a
Three Month Period*

Footage of film used	411,653 feet
Total of number of splices	6,892 "
Total number of splices remade	211 "

Nature of Defects in Splices

Loosened	133 feet
Unmatched perforations	10 "
Damaged perforations	5 "
Wide or curled	51 "
Cracked along splice	12 "

This inspection record covers the period between June first and September first, 1927. It may be assumed as an average three month record, this particular period being selected only because it best represents current conditions exactly as we find them. It may be noted that during this period we found it necessary to remove and remake a total of 211 splices. The time consumed in actual repair work when once the defects had been found was not large, but when it is considered that this work entailed the careful examination of each one of nearly 7000 splices it can be seen that the matter is one of considerable import to projectionists. Also, it must be remembered that this film was received from the exchanges in supposedly perfect condition for projection.

Of the total number of splices that were remade, 133, or 63% of them, were remade because they were either in a loosened condition when received from the exchange or else began to open up during the three days run of the print. The great majority of faulty splices of

this type were neat appearing, machine-made laboratory splices. These were obviously the original splices made in assembling the print. It is a fact that most of the laboratory splices in the general run of film are good splices, but there are far too many of them that are not reliable.

Here is a situation which can be largely remedied if those who are in a position to do the job will only do it. There is no technical problem involved in the process of making a good splice, and the method is neither a difficult nor complicated one.

With a good splicing machine and with suitable cement, both of which are available on the market, and by using due care and proper methods, it is no more expensive or difficult to make a reliable splice that will have a long useful life than it is to make one that will be a potential cause of trouble until removed or remade.

It is noteworthy that trouble of this nature in the film which we receive has been virtually eliminated by one of the larger producers, and if the problem has been satisfactorily solved in this quarter, there seems no good reason to believe that it cannot be in the others.

Intermittent Movement of Film Must be Accurate

Troubles of a more technical nature, which are of recent development, and which concern the position in which the film frames seat at the film aperture, are giving many projectionists, and probably some who are not projectionists, considerable food for thought.

The placing in rapid succession of many thousands of film images at the aperture during the projection of a picture is a precise job. The mechanical process of doing this must be pretty nearly right and so, likewise, must be the film. Each successive frame of film must be brought to an abrupt stop at the aperture in virtually the same position occupied by all the preceding frames. The permissible tolerance for displacement of any frame or series of frames from this common position is very slight if projection faults of a certain nature are to be avoided.

Tension applied along the film tracks on the projector operates to maintain the frame of film in a flat plane at the aperture. Opposed to this tension is a tendency for the film to flex in the direction of the light source and assume a sort of "cupped" position while motionless in the light ray. The amount of bulge that will occur will depend upon certain characteristics of the film stock, the amount of heat incident on the film, and the photographic density of the film image.

When the Lens is Working at a Large Relative Aperture, Changes in Film Density will Require Re-focusing of Lens

So long as the film is in normal condition and continues to seat in a normal manner at the film aperture, the projection lens will focus all of the frame images equally, and the picture will appear sharp and well defined. Under conditions where the projection lens is working at a large relative aperture and consequently with a depth of focus that is slight, it may be necessary occasionally to re-focus the lens when pronounced changes in film density occur.

This may require considerable attention while the act of doing this will be noticeable on the screen unless carefully performed. However the point I want to make is that when film which is in a normal condition is being projected the control of the focus of the picture is in the hands of the projectionist, and it is his own error if the lens is not re-adjusted when it should be.

Buckled Film Causes in-and-out-of-Focus Effect on Screen

With film which is in a buckled condition, a very different and difficult situation is encountered. The term "buckled film" is here used to designate film which has a decided tendency to flex first in one direction and then the other in a rapid and irregular manner while passing the film gate of the projector—this, regardless of the tension which is applied to it in the projection mechanism.

One sequence of frames will seat at the aperture as they should, another series may follow which will not, projection being accompanied by a distinctive rattling sound that is characteristic of film in this condition. The maximum difference in displacement between these frames, which bend in alternate directions, is too great for the lens to accommodate, and a pronounced in-and-out-of-focus effect is experienced on the screen. Trouble of this nature has of late become quite general. That it is a serious problem seems agreed upon; but there seems to be some difference of opinion in ascribing causes.

Some have placed the whole blame upon the illuminating system of a widely-used and excellent type of reflector arc light source, holding that this system, when working the projection lens at a large relative aperture, places too severe limitations upon permissible displacement of film at the aperture; also, that troubles of the nature just set forth occur only when a light source of this type is used. With this conclusion I do not agree. Trouble may be aggravated under these conditions, especially when accompanied by much heat,

but if the film is in a normal condition, no trouble at all would be experienced. The trouble is of too general a nature to pin it down in this quarter.

Another opinion set forth admits the circulation of much buckled film and allows that this film is responsible for the epidemic of focusing troubles. The cause for the film becoming buckled is blamed to the vogue for brighter and still brighter pictures, which has resulted in film being subjected repeatedly to much higher orders of heat than has formerly been customary.

My own opinion is that the heat question has undoubtedly raised new problems but has little effect upon causing film to buckle in the manner that has been described. Experiences with new film which had not been projected previously, and in which the trouble was very bad indeed, is one of the things which leads me to the conclusion that most of the trouble of this nature occurs before the film has been placed in circulation.

Buckling Occurs at Separated Points in Print

I have many times observed while projecting buckled film that the trouble would suddenly cease; be absent for perhaps several hundred feet; and then abruptly commence again. Examination disclosed the fact that the buckling started or stopped at splices which were made at the time the print was assembled. This seems to point out that some sections of the print had been subjected to conditions to which the other sections had not been. If the cause for the film becoming buckled occurred after the print had been placed in general circulation, the line of demarcation between good and bad could not possibly have been so well defined.

On several occasions I have taken sections of buckled film which were giving us trouble and have had them projected with a different type of light source system than that which we use and under more favorable optical conditions to determine, if possible, the comparative results.

It was difficult to determine if there was any difference under the more favorable conditions, though personally I think that some improvement could be noted. There surely was no marked difference, however, and the matter of real interest is that the in-and-out-of-focus effect persisted in all test cases.

Occasional instances of buckled film have always been experienced, but these few cases cannot be compared in importance to the

large amount of film in this condition which has recently come into circulation. This, together with the more severe optical and heat conditions under which it is now commonly projected, has made the problem a serious one.

Co-operation is Needed to Remedy Projection Troubles

The matters which have been set forth are some of those which have been giving much concern to the projectionist but for which he alone had no remedy. He can do little more than state the nature of his troubles, indicate as best he can their probable sources, and ask that those in other fields of the industry who are also concerned in the problems in a technical way shall co-operate in arriving at the best solution.

DISCUSSION

MR. DENISON: I should like to ask Mr. Gray if his complaints regarding splices are general or are they confined to one or two companies.

MR. GRAY: In my paper I took pains to say that the trouble caused by reason of machine-made, laboratory splices becoming loosened and opening up had been virtually eliminated by one of the larger producers and that if one had done it effectively, the others could take care of the field in the same way.

MR. CUFFE: With regard to the variation of density of the image affecting buckle, I don't see how a difference in density can cause a difference in focus when it is all in the same plane.

MR. GRAY: The film as a whole does travel in a common plane, but the individual frames, as they are successively exposed to the light, do not remain flat. Because of the heat absorbed by the film, all the frames have a tendency to "bend" or "bow" toward the light source. The greater the photographic density of the image, the greater the degree of absorption of heat and therefore the greater the "cupping" that will occur. For instance, through a number of successive scenes the film may perhaps have but a small varying density, and all frames therein will be in focus without any adjustment of the projection lens. But when an insert of high transparency comes along, the frames will not bend as much as those of average density, and the lens must be readjusted accordingly.

MR. CUFFE: It seems to me that this would take place only with a very wide angle lens.

MR. GRAY: Those I am using are 6.5'' equivalent focus. The important point in this matter is the relative aperture at which the lens is working rather than the focal length. When the lens is working at high speed, the depth of focus is slight and much refocusing may be necessary. When working at a low speed, perhaps no difficulty at all will be experienced.

MR. CUFFE: With regard to buckling: I think that one of the causes is that new film dries quicker along the sprocket holes than in the center, so that the outside is shorter than the center of the film, which causes it to buckle. A thoroughly dried out film will not buckle.

MR. CRABTREE: I think the fact that different portions of the film buckle to different extents can be explained by the difference in moisture content of different sections of the film. When assembled, probably one scene has been dried excessively and another section has not been dried to the same extent, so that they are in equilibrium with atmospheres at different humidities. In the projector, the gelatin coating of the moist film shrinks more and therefore buckles more than the coating of the dry film.

There are several ways of diminishing the tendency of film to buckle. One very obvious way would be to make the film base thicker, but this costs money.

Toning with uranium gives a warm brown or red image and changes the size of the silver grains, and we observed that the tendency of the film to fire was about one-quarter that of a black and white image. The buckling is due to heat, so that if we can reduce the degree of heat absorption of the film, we will reduce the tendency of the film to buckle.

MR. RICHARDSON: Is not a great deal of film buckling trouble during projection caused by improper drying of the film? Would it not be possible to establish a standard for drying, so that the film would leave the laboratory in the best possible condition for use?

I was impressed by Mr. Gray's remark that the poor condition of films received by projectionists often discouraged them from making any attempt to care for them properly or from making any especial effort to prevent damage to them while in their possession. For example, I presume I am well within the limits when saying that during the seventeen years I have been technical editor of the Moving Picture World I have received ten thousand complaints concerning punch hole change-over markers in the tail end of reels of film. Every possible effort has been made to lessen or eliminate this evil. The

exchange will call the projectionist a variety of uncomplimentary names for thus punching holes in film but will itself calmly proceed to punch from one to half a dozen "identification marks" in film, each mark containing from five to ten letters or figures, and each letter or figure from twenty to fifty holes. The net result is that when we get after the projectionist for punching change-over marker holes he very often sends in an assortment of these markers and pertinently inquires why the exchange complains about a mere half a dozen or so holes when the exchange itself punches maybe several hundred holes in each reel.

MR. MCGUIRE: Last July, Mr. Pettijohn, counsel of the Motion Picture Producers and Distributors of America and twenty-nine film boards of trade told me that rules were being formulated which would penalize damage to film. While this might increase or decrease the difficulties of the projectionist, it should eventually fix responsibility for damaging the film and so correct the conditions referred to by Mr. Gray.

MR. CRABTREE: I think Mr. Richardson's suggestion is entirely practical. I have suggested it before. After the film is dry, it should go through a further chamber maintained at constant temperature and humidity. In this way, if too dry the film would have an opportunity to absorb moisture. I notice a French patent has just been granted for a processing machine with such a subsidiary humidifying cabinet.

With regard to buckling, any means of reducing heat in the gate will diminish buckling. There have been a number of devices put out by foreign manufacturers for diminishing heat in the gate. The usual method is to blow a current of air on the gate proper. Projection manufacturers could help considerably in avoiding buckling by supplying such attachments for their projectors.

MR. CUFFE: With regard to buckling, I don't think that excessive heat has much to do with it if the film is really conditioned. The present-day production is not fast enough for the consumption, as it was years ago. Films used to have a chance to dry out; but now within six hours after being finished, they are on the way to the exchange and then they are immediately put on the screen.

MR. BRIEFER: Not long ago I had the pleasure of visiting one of the large finishing plants where prints are made in great numbers. This laboratory has an automatic printing and developing machine with a chamber for drying the film, and the whole process is a con-

tinuous one. The film is wound outside of the drying chamber on reels, and I observed that some of the reels wound up round and true, while others wound up octagonally. The differences may be due to variations in the drying conditions in the chamber. When a strip of about six feet of this octagonally wound film is held up vertically, it twists in a spiral, while that wound smooth and true hangs straight and also has a tendency to be convex on the gelatin side. The other has a tendency to be concave on the gelatin side. When scenes from such films are spliced together, there is certain to be a difference relative to the focal plane of the print when it passes through the gate. I believe this to be one of the chief causes of the trouble. The difference in density referred to may result in a variation of heat transfer, but it is difficult to see how that would seriously affect the screen images. The chief difficulty is due, perhaps, to some errors in processing the film.

MR. TOWNSEND: There is a reel manufacturer in Rochester who asked me what I considered would be a good reel, and I told him. He then manufactured a good reel to sell for twenty-five cents. I heard nothing further about it for about five years. About a year ago he gave me a reel with a hub more than $1/16''$ larger diameter than it should have been. I told the representative, "I don't see why you put out such things," and he said: "We tried to put out a decent reel and the trade wouldn't pay for it; they wanted one for eleven cents." When an expensive roll of film is put on such a reel and the hole is so large that the film slips around on it when re-winding, there is likely to be a slash cut in the hand. We have an average of two cut fingers a week in our screening room, where two men put film in condition for the screen. I don't see how an exchange can expect a projectionist to take care of film, when there is a constant danger of getting a cut hand and possible infection. It gives the man an impulse to throw away the reel including the film.

The buckling has been of concern to me for some time. Three distinct kinds of buckling have been mentioned. I think some one should work along lines to eliminate each one of the three. In the projection of brand new film or any film, the density determines the amount of heat absorbed. The denser the film, the more it will cup away from the projection lens and towards the light. A title buckles so much in a Simplex that it rubs against the aperture plate and causes a scratch. On examination we can find what projector the film has been through. There is another type of buckling

caused by the film being heated more in the center. That is common but not so much so as where the film has dried on the edges and left the center longer. That is the most common type encountered. It occurs on film one to three months old. While there is room for improvement in the laboratories, there is more room for improvement in film after it has left the laboratory. The conditions are sometimes encountered of four to eight reels of film being put in a container and shipped around and perhaps placed near a steam radiator in the winter and then put in a cold damp atmosphere. Especially if the film is open in the box or is left on the machine, it will dry on the edges, which is our most common difficulty. In Rochester we book first-run pictures but don't always run them at once. Oftentimes if we hold up a picture three or four weeks or a month, it is impossible to get a brand new print, the new one cannot be used. It is not uncommon that a print a month old is in that condition. I have had prints from exchanges, not any one in particular, where they have remained on the shelf for three or four weeks and become very dry on the edges, and it is absolutely impossible to maintain focus with such films. That is the most malignant form of buckling. I think information should be given exchanges, and efforts made to get them to use better care in shipping. I am in favor of tin cans inside the case, and I would go so far as to recommend placing a sealing tape around each can and storing in this way.

MR. RICHARDSON: This discussion illustrates the value of this organization. We are getting down to an understanding of things which have been injuring the industry for a long time. I have tried to get the adoption of a blower air blast at the aperture, but I have not been able to accomplish anything. Perhaps this paper and discussion will encourage manufacturers to consider the matter more seriously. Many projectionists are using too high an amperage with resultant abnormal heat at the aperture which serves to aggravate the conditions we have been discussing. Close attention to the use of carbons of suitable diameter is very important. Mr. Gray is getting a result with very low amperage using a reflector arc which is just as good as others obtain with twenty-five amperes, demonstrating that the high amperage and high heat are unnecessary.

MR. R. C. HUBBARD: We are constantly getting complaints about buckling of film, and I can say from my experience that film rarely leaves the laboratory in a condition which is conducive to buckling in the projector. Almost all laboratories today have air

conditioning plants, and the film as it goes through the various processes takes the condition of the air in the plant. There is no special machine or cabinet required for conditioning, and as the film goes through for examination it is in proper condition. When it leaves the laboratory it goes to the exchange, and I don't believe there are any exchanges having proper conditions for storing film. This situation should be improved. Also, as Mr. Townsend explains, the shipping of the film should be in cases where it could be kept under the proper conditions of humidity. This is entirely possible, and if such care is taken, it will eliminate buckling.

MR. RICHARDSON: Then you believe that heat has little to do with buckling? Is it not a fact that the greater photographic densities causes more buckle? That is a recognized fact in projection.

MR. R. C. HUBBARD: I am speaking of the experience we have had with film returned to us.

PRESIDENT COOK: There is an opportunity for the Nomenclature Committee to distinguish between the different forms of malformation of the film—longitudinal, transverse, and window frame style.

MR. GRAY: In answering Mr. Hubbard, I should like to tell of an interesting case of buckled film which I recently observed. About a year ago we ran a print of a certain film which apparently had never been projected. On screening the film we found that out of three or four different reels much of it was badly buckled and caused a pronounced oscillating, in-and-out-of-focus effect on the screen. This was so bad that we could not use it, and we had to obtain another print.

Each Tuesday we have a Review Day, running films which we have shown before. Two weeks ago we again presented the same film subject to which I have just referred. When this was screened, I noticed it was buckling badly, and upon referring to the print number on our record, I found it to be the same print which had given us trouble a year ago. So far as I could judge by memory, there was as much buckling and no more, after a year of service, than when it was first used.

MR. HUBBARD: I certainly believe Mr. Gray's statement. That might be due to some effect in one roll of the film base itself, but the majority of the complaints we have from buckling will, of course, be more or less from throughout the reel. We can recondition that film within a short space of time by putting it in a properly conditioned room.

ACOUSTICS OF MOTION PICTURE THEATERS

F. R. WATSON*

Introduction

THE necessity for adjusting the acoustics of motion picture theaters has not arisen so often nor so seriously as in the case of churches and other auditoriums. This is because motion pictures are usually accompanied only by organ music, which does not present so great an acoustical problem as speaking. In some cases, however, in addition to the motion pictures, there are songs and speaking numbers, educational addresses or other features, so that it becomes increasingly important that such theaters be adjusted to have good acoustics. There is also to be considered the development of the talking motion picture, which depends markedly for its success on a room properly designed for speaking.

The acoustics of rooms is a subject of modern development and became an acute problem when large auditoriums were built with steel and hard plaster constructions. As a result, only a few architects are informed concerning the scientific progress in the subject not only because the development is comparatively recent (since about 1900) but also because the published accounts of acoustics are not easy to understand, involving as they do an exponential equation, and because of the aversion of architects to being obliged to consider a new element in the already complicated problem of buildings with an additional expense.

Active progress in the acoustic adjustment of rooms has been stimulated by commercial companies who have developed various products that have acoustic merit in greater or less degree and who present the matter by modern sales methods to the parties involved. It appears important at the present time to set forth discussions of the subject that are based on scientific investigations and yet which are simplified as far as possible for the information of the layman who is confronted with the necessity of acoustic installation.

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Action of Sound in a Room

What is desired for ideal acoustics is that the sound reaching an auditor in any part of a room shall be of suitable loudness and distinctness for comfortable hearing with an elimination or control of echoes, reverberation, "dead spots," and other faults. To a great extent, it is possible to secure such ideal conditions; and it is the purpose of this paper to explain some of the fundamental actions of sound and to show how motion picture rooms may be adjusted so as to have good acoustic properties.

Sound travels out in spherical waves from a speaker or a musical instrument with the great velocity of 1120 feet per second at ordinary temperature, about as fast as a rifle bullet. As a result, sound will be reflected back and forth about 30 times a second between walls of an auditorium 40 feet apart. Because of these rapid reflections, an auditorium of usual size is filled with sound in a small fraction of a second, thus-insuring a *loudness* in every part of the room.

A speech sound, such as any one of the words uttered by a speaker that requires about one-tenth of a second for its completion, thus travels 112 feet before the word is finished; so that, in the open air, a speaker would be at the center of a sphere of 112 feet radius that would be filled with the sound of the word. In an auditorium, the sound waves would be reflected several times in traveling 112 feet, so that instead of a sphere there would be overlapping bundles of sound traveling in every direction and completely filling the room with the sound of the word before the speaker finishes saying it. In the open air, the utterances of a speaker progress with practically no distortion, and perfect acoustics are obtained. In a room, however, the reflected sound joins with the direct sound and has large possibilities of distortion. A study of the action of the reflected sound is thus the most important consideration in obtaining good acoustics in a room.

When sound arrives at a wall or ceiling, it is reflected, absorbed, and transmitted in varying amounts depending on the nature of the reflecting surface. A hard plaster wall, for instance, reflects 95% or more of the incident sound and therefore absorbs but little; whereas a layer of hairfelt one inch thick may absorb 50% with a correspondingly smaller reflection. The following table gives the absorbing values of common materials.

TABLE 1.

Absorbing Coefficients of Common Materials

	<i>Coefficient per sq. ft.</i>
Open window (absorbs all sound falling on it)	1.00
Hairfelt one-inch thick	0.55
Plaster walls	0.025 to 0.034
Glass	0.027
Concrete	0.015
Varnished wood	0.03
Carpets	0.15 to 0.25
<i>Individual Objects</i>	<i>Absorbing Units Each</i>
Audience (per person) about 15 sq. ft. of clothing	4.70
Wood seat	0.20

Inspection of this table shows why a room lined with plaster, glass, and wood is reverberant—the surfaces absorb but little, and the sound may be reflected 200 to 300 times before it becomes inaudible. The use of carpets, hairfelt, and similar materials increases the absorption and furnishes the means for controlling the reverberation in a room.

Absorption may also take place when a wall vibrates under the action of sound. The pressures and rarefactions of the sound waves exert a sort of push and pull effect on the wall, and while each effect is small, the total effect may be large—as many as 200 to 2,000 pushes and pulls per second for ordinary sounds, depending on the frequency. The absorption in this case is due to the transformation of the sound energy into mechanical energy of vibration. Wooden seats in rooms may often be felt to vibrate when music is played.

Reverberation and Its Control

As already explained, the sound energy in a room will persist too long if the surfaces are not sufficiently absorbing. The continued reflections under such circumstances prolong the sound and produce what is called a *reverberation*. Speech is then distorted and music does not have the qualities desired by musicians. To control these defects, it is necessary to install a calculated amount of absorbing material and to have the reflecting walls of suitable shape and in selected positions.

An all important question arises as to the amount of sound-absorbing material that should be installed for good effect, and this

has been answered by obtaining the opinions of auditors regarding auditoriums already possessing good acoustics. Before discussing the answer to this question, it should be stated that the reverberation depends also on the *loudness* of the sound and on the *volume* of the room; larger rooms with the reflecting walls farther apart will have a longer reverberation. These factors may be put into the statement: the time of reverberation t is directly proportional to the loudness of the sound and to the volume V of the room and inversely proportional to the absorbing material a present. Putting this in the simplified equation, we get: $t = 0.05V/a$, where the factor 0.05 represents a standard loudness.¹

As a simple example, take an actual room 148 feet long, 57 feet wide and 23 feet average height; the volume being approximately 194,000 cubic feet. The absorption a in the room is calculated from the coefficients in Table 1 as follows:

Wood floor	8436 sq. ft. @0.03	.....	253 units
Plaster ceiling	8436 " " @0.033	.....	278 "
Plaster on tile walls	9430 " " @0.025	.....	236 "
1,000 seats	@0.15	.....	150 "
Absorption for the empty room			..... 917 "
Average audience (330 people) @4.7			..... 1500 "
Absorption with average audience			..... 2417 "

It should be noted that the absorption of the audience is nearly twice that of the surfaces in the room. This is due to the clothing worn. Continuing with the calculations, we get the time of reverberation for the empty room to be:

$$t = 0.05 \times 194,000 / 917 = 10.6 \text{ seconds}$$

and for the average audience:

$$t = 0.05 \times 194,000 / 2417 = 4.02 \text{ seconds}$$

That is, a standard sound will persist 10.6 seconds in the empty room and 4.02 seconds with an average audience present. Comparing these results with those for auditoriums having good acoustics, it is found that the times are too long and that the room will be too reverberant, so that sound-absorbing material must be introduced to make the reverberation less. For guidance in such installation, the following table of optimum values of the time of reverberation and absorbing material has been prepared.

¹ W. C. Sabine, "Collected Works on Acoustics"

TABLE 2.

Optimum Time of Reverberation and Optimum Absorption

<i>Volume of Room</i>	<i>Optimum Time</i>	<i>Optimum Absorption Units</i>
3,300 cu. ft.	1.0 seconds	165 units
12,900 "	1.1 "	585 "
33,000 "	1.2 "	1,380 "
63,000 "	1.3 "	2,400 "
117,500 "	1.4 "	4,200 "
186,000 "	1.5 "	6,200 "
276,000 "	1.6 "	8,600 "
407,000 "	1.7 "	12,000 "
550,000 "	1.8 "	15,300 "
750,000 "	1.9 "	19,700 "
1,000,000 "	2.0 "	24,800 "

Inspection of the table reveals one important fact—that the optimum time is short, not exceeding 2 seconds for an auditorium of 1,000,000 cubic feet. Defective auditoriums usually have too long a time of reverberation.² Apply these optima to the case of the room just described. The volume is 194,000 cubic feet, which would require an optimum time of about 1.51 seconds, and this will be obtained when approximately 6,420 units of material are in the room. Suppose optimum acoustics are wanted for a two-thirds capacity audience, for which the room already has the absorbing units of 917 for the empty room, to which should be added 3,000 units for a two-thirds audience, giving a total of 3,917 units. To this must be added 2,500 units to give the optimum of 6,420 units. If hairfelt is selected as the sound-absorbing material, the 2,500 units will require 4,550 square feet ($4,550 @ 0.55 = 2,500$ units), which may be applied in panels on the ceiling.³

Summing up, the times of reverberation for the corrected room will be:

t (empty corrected room)	$0.05 \times 194,000 / 3,420 = 2.82$ seconds
t (with one-third audience)	$0.05 \times 194,000 / 4,920 = 1.97$ "
t (with two-thirds ")	$0.05 \times 194,000 / 6,420 = 1.51$ "
t (capacity audience)	$0.05 \times 194,000 / 7,920 = 1.23$ "

Optimum acoustics will be obtained for the two-thirds audience, but the conditions will be good for the capacity audience and also for the empty room when used for rehearsals and organ practice.

² F. R. Watson, "Optimum Time of Reverberation," *Architecture*, May, 1927.

³ See list of commercial materials now available for acoustic treatments. "The Absorption of Sound by Materials" by F. R. Watson, *Bulletin 172*, University of Illinois Engineering Station.

Where Should Absorbing Material Be Placed?

Having determined the amount of material needed for optimum acoustics, the question arises as to where the material should be placed. Experience shows that some walls in a room are more likely to give troublesome reflections than others. For instance, a rear wall may reflect sound to an auditor near the speaker and produce an *echo*; that is, a repetition of the direct sound that is noticeable. This result follows if the time interval between the direct and reflected sounds is about one-tenth of a second or more, for which the difference in path of the two sounds is at least 112 feet ($1120 \div 10 = 112$), and the reflecting wall is about 56 feet distant from the auditor. With the wall at a greater distance, the echo will be worse. If the reflecting wall is curved, which is often the case, a focusing action follows and the echo is more pronounced. To reduce this defect, it is desirable to place sound-absorbing material on reflecting walls at some distance from the stage. This practice finds commendation for another reason. Experiment has shown that better acoustics are obtained if the space about the speaker or musician is left reverberant while the absorbing material is placed on the walls nearer the audience.⁴ Under these circumstances, the speaker or musician finds that it is "easy to speak or play," and the auditors find the listening satisfactory.

Application to Motion Picture Theaters

In the adjustment of the acoustics of motion picture theaters, two types of room may be considered. First, there is the simple case where the room is long, narrow, and rectangular, with a fairly low ceiling, and in which the only sound to be considered is the usual organ music. Good acoustics usually result in such a room if the space about the organ is free from heavy plush curtains and other absorbing material and if at least a fair sized audience is present. The organ music is beneficially reënforced by the nearby surfaces and on passing to the auditors is absorbed by their clothing, so that a pleasing acoustic effect follows. With only a few auditors present, however, there is not enough sound-absorbing clothing to reduce the reverberation, and the music will not sound so well. For such a case, absorbing material can be installed, preferably on the ceiling, with good effect.

⁴ "Optimum Conditions for Music in Rooms," *Science*, August 27, 1926.

If the theater is used for speaking and music, as well as for motion pictures, it becomes more imperative to consider the acoustic conditions. This type of room, which is usually larger than the first room considered, would require the adjustment described in detail earlier in the paper. A calculated amount of sound-absorbing material, depending on the size of the room, should be installed on carefully selected surfaces to give the best reverberation, while special stage walls and ceiling might be arranged to increase distinctness of speaking. It should be noted that the audience constitutes a varying sound-absorbent that must be reckoned with. In some cases the absorption of the audience is the greatest item in the room. In the correction of acoustics, the practice is to install enough material to make a room independent to a great extent of the audience.

Studios for Making Talking Motion Pictures

What is desired in talking motion pictures is as accurate a reproduction as possible of the original sound. There appear to be two steps in accomplishing this object: first, to make a record that accords with the original, and, second, to produce this record under conditions that give the best acoustic effect. Good results in recording sound have been obtained in specially designed rooms. Heavy draperies and other absorbing materials are installed on the walls and ceiling, this reducing the reflection so that the sound coming directly from the speaker or musical instrument produces the main effect. It is the reflected sound that joins with the direct sound and produces distortions. By greatly reducing the reflection, the conditions for perfect outdoor acoustics may be approximated. Extraneous sounds are prevented from entering the room by special walls made rigid and heavy.⁵

The best reproduction of the sound should take place in a room adjusted for good acoustics in the same manner as for a speaker, as described earlier in the paper. That is, it is only necessary to consider that the speaker or musician is replaced by the instrument reproducing the recorded sound and that the intensity and character of the reproduced sound is practically the same as the original.

⁵ "Sounds Recorded on 'Movie' film," by A. P. Peck, *Scientific American*, Sept., 1927.

Conclusions

The important requirements for good acoustics in a room may be enumerated as follows:

1. The sound in a room should have sufficient loudness, a condition that is brought about by reflection from the various surfaces of the room which reënforces the direct sound. If the speaker or musical instrument produces a weak sound, no arrangement of the room will increase the loudness except by the use of an electric loud speaker.

2. The reverberation or persistence of sound should be controlled by installing an amount of sound-absorbing material in proportion to the volume of the room.

3. Speaking should be distinct. For this purpose, it is desirable to arrange the reflecting surfaces near the speaker and to apply absorbing material to selected walls.

DISCUSSION

MR. ISAACS: Are any statements made as to the best shape of the room?

MR. WATSON (communicated): The best shape of an auditorium for acoustic effect is rectangular. Curved walls are likely to produce acoustic defects unless modified by coffering or other features, or by application of sound-absorbent.

MR. BURNAP: As a comment on the statement that the reverberation period in radio broadcasting studios is adjusted for the optimum value, I have understood from other authors that the practice in radio studios is to over-correct by an excess amount of absorbing material. The reason given for over-correcting in the studio is that the final broadcast sounds are further affected by the reverberation period of the room in which the loud speaker is located. It is desirable, therefore, to keep the broadcasting studio reverberation period low, as the final result depends on the combined effects of the studio and the loudspeaker room.

VOICE: I had a little experience with organs, and you can take the quality out of an organ by heavy rugs and too much drapery, and care must be taken not to take too much out of the quality. Colonel Fabian has a private laboratory about thirty-five miles outside of Chicago and has made a thorough study of materials for use with organs.

MR. WATSON (communicated): Colonel Fabian is the patron of

an acoustic laboratory at Geneva, Illinois. The actual acoustic work is in charge of Dr. Paul E. Sabine, a cousin of Professor Wallace Sabine of Harvard University, who was the pioneer in acoustical correction work. Colonel Fabian is a business man with support of scientific work as a hobby.

MR. STEWART: I was rather hoping that the paper would say something about Celotex, because the Vitaphone Company experts use nothing else; DeForest uses only Celotex. The camera booth for Dr. DeForest is of Celotex with a space between filled with hair felt.

MR. WATSON (communicated): I have made no comments about commercial materials in my paper but information about sound-absorbing materials may be found in Bulletin 172, "The Absorption of Sound by Materials," by F. R. Watson, Univ. of Illinois Engineering Experiment Station.

MR. ROSS: I should like to say, referring to Carnegie Hall, New York City, that if an auditorium of a sufficient size can be built, and if certain dimensions are observed, perfect conditions of acoustics can be obtained. As far as I know, they are not using sound materials on the walls, and I think this auditorium has the finest acoustic properties of any building of its kind.

MR. BAUER: I think that applies to the Cleveland Auditorium. A few years ago it was the largest edifice of its type in the world. I heard an orchestra of a few hundred pieces and was approximately one block away in the building and could hear and distinguish each note without the slightest trouble, and friends sitting closer experienced the same sensation I did, and I could not note that they used absorbing materials. It seemed to be in the design and construction of the building.

MR. FARNHAM: I believe I can answer Mr. Bauer's question in regard to the Cleveland Public Auditorium, and my answer may possibly apply to Carnegie Hall. There are at present available a number of acoustic plasters which can be applied to the walls at the time the building is being constructed so that the acoustical condition of the completed building is satisfactory. Since the plaster is put on at the time the building is built, it is quite possible to incorporate it into the general decorative scheme in such a manner that it is not visible to the casual observer. A close examination of the walls is required in the case of the Cleveland Public Auditorium to note the use of this plaster.

MR. STEWART: You probably remember when the Century Theater in New York was opened. The acoustics made it almost impossible to give a play, so they intermeshed the ceiling with fine wire and it made a great improvement.

MR. COFFMAN: The Century Theater case was one of the first experiments that Professor Sabine worked on. His method was rather interesting from the photographic standpoint. Professor Sabine made cross-section models of the auditorium, and by using an electrical spark as the source of sound on the cross sectional stage, he succeeded in photographing the sound waves and in obtaining a record of their reflections. In this way, he was able to determine what happened to the waves and to correct the acoustics by placing absorbing materials at the proper points. I believe this case largely established the technic of acoustic correction.

MR. ROSS: I should like to add that I know a case in Chicago where a plain wall building gave bad echo. They stretched wires across the hall and kept adding them until they broke up the echo.

PRESIDENT COOK: I believe that is a common method. I know the Denver Auditorium suffered that way and the cross wires corrected the effect, but of course they are unsightly.

MR. WATSON (communicated): Wires in an auditorium are practically useless. If an auditorium with wires has good acoustics, this must be due to other features—carpet, upholstered seats, or other absorbents. The Denver Civic Auditorium, for example, has a considerable amount of absorbent installed.

IMPROVEMENTS IN LABORATORY PRACTICE

VICTOR A. STEWART

IT SEEMS peculiar that motion picture engineers have overlooked the aid which might be obtained from the other arts and be used to overcome some of the troubles encountered in our work. Several of such combinations have occurred to me and a few have already been adopted. I propose to lay some of these ideas before you, as they may perhaps suggest other helpful applications.

Static

First, I will start with that bugbear "Static." As children we used to rub a glass rod with a piece of wool, cotton, or perhaps cat's fur and were then able to pick up small pieces of paper, pith, or other light substances. We had accumulated frictional or static electricity in that rod. Some forty odd years ago I was apprenticed to a so-called electrical engineer, and I was deputed to conduct a series of experiments to increase the frictional electricity generated by the glass cylinder and the Wimshurst machines by trying different alloys of tin, zinc, and mercury, and various grades of silk, cotton, and wool. When I entered the motion picture field I was soon made aware of the static trouble encountered by cameramen. One of them showed me the working of his camera, and I realized that it was actually a miniature Wimshurst machine using that easily electrifiable substance, celluloid, which is passed over silk velvet, a material most likely to charge it with static, to be later discharged when it comes in contact with the metal aperture plate. We all know that electricity cannot be generated by two like substances, so that the obvious solution was to procure a celluloid surface on which the film could travel. For many years I was with the English Welsbach Company, and while there I learned that a Frenchman named Chardonnet had perfected an artificial silk having a cellulose acetate base. This idea was taken up by a Spaniard named Plaisetty, who used this new base in place of the usual Sea Island cotton or blend of silk and cotton for a foundation in the manufacture of gas mantles. This Pyroxylin silk was manufactured extensively in Germany,

and the small village of Eberfeldt became a thriving city as a consequence. Stockings, gloves, etc., are made of this material which is now called "Rayon." It is also made into velvets and plushes. I procured some of this velvet and applied it to the light trap of a magazine with the immediate result of freedom from static trouble. In 1919 I communicated the idea to Mr. Jules Brulatour, who sent some of the velvet to Mr. Lovejoy at the Eastman Works. He made a test and confirmed what the experiment had shown, but there it died as far as I was concerned. Everybody who handles unexposed film should be provided with Rayon gloves, and every track over which it travels should be covered with artificial silk, and the light trap of every camera magazine should be similarly equipped.

Measuring Light in Printing Machines

When I was with the Welsbach Company, one of my duties was to determine the candle power of the gas mantles by means of a photometer. I made a hobby of photometry and built many photometers and invented a new disc to be used with them. When I learned something of motion picture laboratory practice I was much surprised to learn that it was taken for granted that the lamps used in the different printing machines were giving the same light as the one on which test exposures were made. Recently, I built a photometer and showed the heads of a laboratory that even new lamps show considerable variation in their light-giving power. Also very few of them are mounted in a truly vertical position to their base, so that a bulb may lean either away from or toward the aperture, giving entirely different illumination. It may also happen that when a nitrogen lamp is screwed home the filament supports come between the filaments and the window, thus admitting less light to the film than if the filament supports were not so placed. The candle power of the lamps decreases with use though the nitrogen-filled bulbs deteriorate more slowly than the vacuum Mazdas. All these differences are causing constant warfare between the printing and developing departments. When I was at the Vitagraph I acquainted Mr. Blackton, about 1917, with the substance of the foregoing and at once he told me to go ahead and have a photometer built. I made a photometer and delivered it to the laboratory, and as soon as the chief saw it he ordered it out and would not allow it in the place. The photometer disc (Fig. 1) consists of an opaque card having a star shaped opening covering a translucent diffusing material of a light

blue color. It is of interest to note that in an interview with Harry Goetz of the Consolidated Film Industries, reported in the paper "Motion Pictures Today" he says, "The lamps in the printing machines are likewise tested every hour to detect deterioration, as they

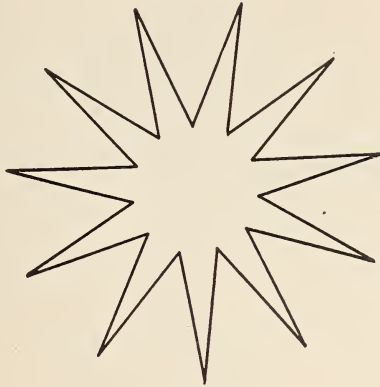


FIG. 1. Photometer Disc.

must be maintained at a constant efficiency in order to secure the uniformity of the prints." He is practically saying in 1927 what I preached in 1917. A simple photometer to measure the light at each printing machine aperture is all that is required.

Rewinding Film

Anybody who has much rewinding of film to do has been greatly inconvenienced by the self-releasing of the spring clip that secures the reel to the spindle of the rewinder. When the clip accidentally opens, the reel of film is projected off with considerable force and shoots to the floor, causing a loss of time and often damage to the film. I have overcome this in my plant by having this finger so arranged (Fig. 2) that it can now engage opposite sides of the opening of the reel, causing an even pressure and preventing the clip from inopportune release.

When examining film for breaks at the perforations, the take-off permits the film to continue unreeling and has to be stopped manually. Usually this means that the location of the break has been rewound for several feet and has to be again unwound to make the necessary repair. I overcome this by means of a simple brake on the dummy



FIG. 2. Front View of Rewind (Dummy) Showing Reel Catch Finger.



FIG. 3. Rear View of Rewind (Dummy) Showing Automatic Brake.

(Figs. 2&3) so that it immediately obeys the action of the rewinder. When the mutilated perforation is found, the inspector stops and the dummy also stops, although it may be quite out of reach of the inspector. The brake is automatic, requiring neither hand, arm, nor leg to control it. The method is very simple and has been used in other arts.

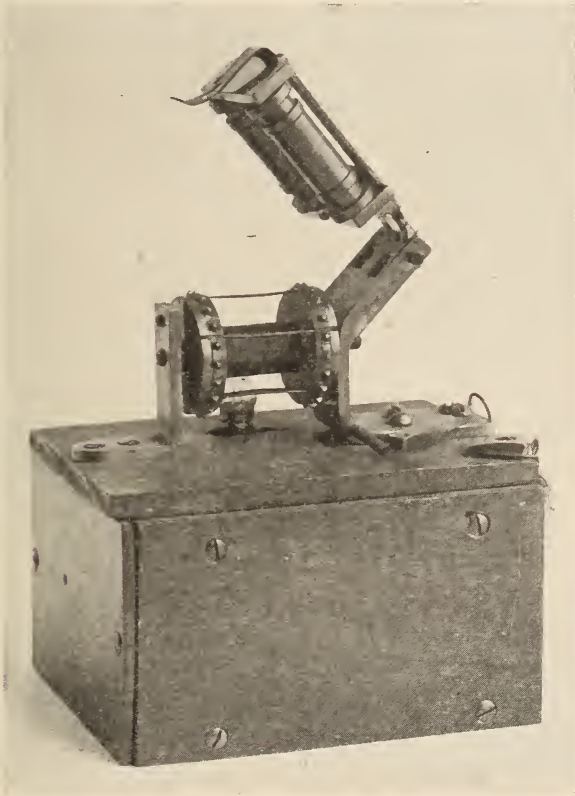


FIG. 3. Misframe Detector.

For examining film to detect misframing caused through incorrect splices, I have devised a simple machine (Fig. 4), which is placed between the rewinders. The film is laid over a sprocket wheel having a number of teeth divisible by four, and between each fourth pair of teeth a guide wire is placed. To start using it, the film is arranged so that the upper and lower edges of the frame correspond with two of

the wires on the wheel so that they are practically invisible. Over the wheel is a plate in which an aperture has been cut. This plate keeps the film in position, and under it at the side is either a mirror or a small electric bulb with a convenient switch, which is able to throw a light through the aperture plate. After winding, say, fifty feet of film, the inspector stops and looks at the opening. If he sees only the frame lines, all is O.K. but, if a third line appears, it is clear evidence that there is a misframe in the previous 50 feet. It is highly

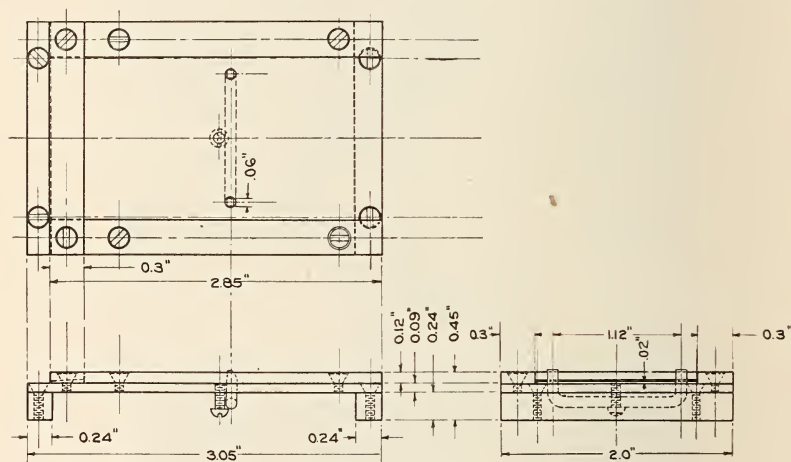


FIG. 4. Cutting and Scraping Block for Splicing,

improbable that there would be two misframes in that length, one offsetting the other. The device may be fastened on a bed in conjunction with a measuring machine, so that they may be worked together or separately as desired.

However we came to adopt razor blades as a means for scraping emulsion off film is a mystery. When a carpenter wishes to smooth a piece of wood or scrape paint or varnish from it, you will not see him use a tool that presents a razor edge. He takes a piece of steel about 4×3 inches in size and about 1/16th of an inch thick. Each side is squared off so that a sharp right-angled edge is presented all along its four scraping sides. When we scrape film we are practically in the same position as the carpenter scraping off paint, so we should use a similar edge for the work we have in hand. I provide my help with screwdrivers that have been hollow-ground on each face, and these make perfect scrapers. When properly hardened they

last a long time, and when sharpening becomes necessary, the blade is rubbed in a vertical position on an oil stone, and the scraping edges are soon restored. At the Vitagraph a very expensive machine was used to re-sharpen the dull razor blades. The awkwardness of the cramped position in which they have to be held is too obvious for me to enlarge upon it. I have met with considerable success with a scraper made from a small toothed wheel mounted on a guide. Each of its teeth offers a fresh scraping edge and lasts indefinitely, while it is impossible to break away the sprocket holes, as is so common with the razor blade.

Most projectionists prefer to make the patch between their fingers and are provided with nothing to give them any assistance when a splice becomes necessary. Can one be surprised at the many misframes that ensue? To help them I have devised a simple cutting and scraping block (Fig. 5) which is so provided with guides that a straight and correct patch is assured.

It seems a pity that those whose duty it is to make patches are not thoroughly imbued with the idea that the film must be perfectly dried before applying the cement. To make a patch while the film has a vestige of moisture remaining is sure to result in an unsatisfactory joint.

Reels

The spring clips on the hubs of film reels leave much to be desired. The difficulty of getting the end of the film under the clip when starting to wind is well known and much cursed, but what is worse is the effect in the projector when the end of the film is reached. The end is so tightly held that the last inch of film is usually broken off and causes a jar to the whole machine that can only have a detrimental result. I have devised a reel (Fig. 6) which by exterior means allows raising both spring ends so that the film can be inserted easily and will slip out freely when the finish of the reel is reached without any jar to the projector.

Leaders and Tail Ends

Any old scrap is being used for leaders and tail ends of a reel of film. I suggest that this Society recommend that something distinguishable be used to indicate which is the beginning and which is the end of the reel and so save time otherwise lost in determining which end is outermost. Let the leader be of clear film with the emulsion removed, and preferably of a gaudy color, and the tail end be

black and opaque. The reason I suggest a gaudy color is that a colorless transparent leader is likely to permit a dense title or the beginning of a picture to show through and be confused with the opaque end.

Operators' Marks at the End of Reel

We are all annoyed when seeing the end of a reel at the many spots of light that interfere with the image on the screen. The

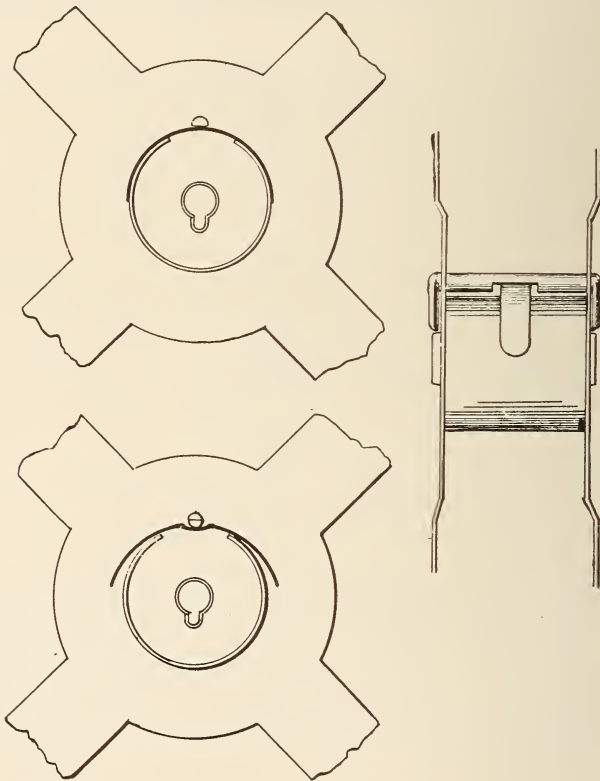


FIG. 6. Side View and Sectional Views Showing Operation of Reel Hub Clip.

operator punches holes in the film for an indication that he is nearing the end. It should be an easy matter to attach small pieces of metal with perforations to match the holes so that the sprocket wheel (or a special device) could make an electric contact and ring a bell or a buzzer or even light a small lamp to call attention at the desired part of the film. Fig. 7 shows a piece of film embodying the idea

though not intended for this purpose, but it clearly shows how the metal could be permanently attached.

Another simple method of accomplishing the same end may be done by the operator if, when his is rewinding, he places a metal washer about the size of a quarter at, say, 40 feet from the end. When the reel is being projected and the end is nearing, the washer

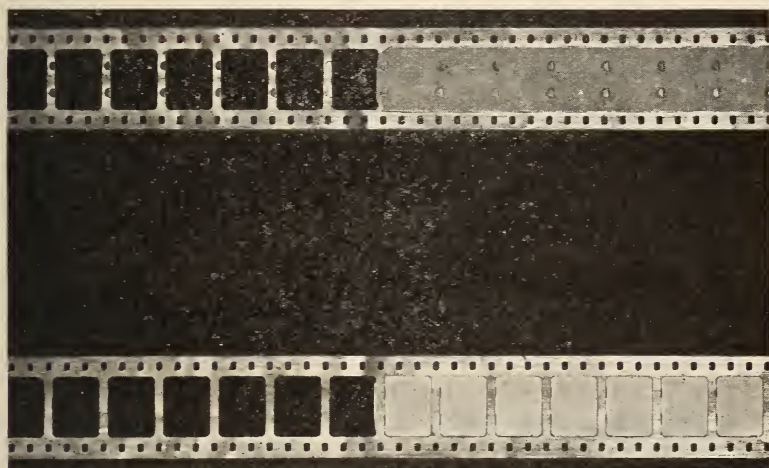


FIG. 7. Front and Rear Views of Film Having Metallic Edges.

will fall from its place and strike the magazine with sufficient force to make a sound loud enough to call the operator's attention to switch over to his other machine.

Cutting and Assembling Film

When assembling film, we are now using rubber bands to keep the short lengths from unraveling and then with difficulty inserting its identifying paper slip. The rubber bands slip off and oftentimes break with a painful snap on the fingers. I overcome this by means of steel bands. Particular attention is called to the easy manner in which a name card can be inserted where the end of the spring engages the film. Also, these can be made of a size to embrace an entire 1,000 foot reel properly prepared with a roughened surface so as to permit printing and writing on the band and do away with the present paper band with its attached twine, which is so frequently broken off in handling and so frequently slips between the film and its reel.

Developing Machines

In the operating of developing machines it seems to me a great mistake to attach the new film to the one being developed by means of the staples now in general use. I suggested that our laboratory use what are known as "hollow rivets" or eyelets—articles that in a much larger size are commonly used for binding together office papers and enclosures. When these small rivets are used, both sides can be so smooth that no rough edges are presented, and scratching from this source during developing is completely overcome. We have all seen the horrible examples of what can be perpetrated by the staples generally used. The machine should be so constructed that the perforations will match perfectly, and then the machine (hand or power) could insert, say, three rivets arranged in a triangular manner so that no play or shakiness is possible. Of course these rivets will be placed so as to interfere in no way with the sprockets that will be encountered later. These "hollow rivets" are made of soft brass or aluminum and are as easily manipulated as the present staples.

DISCUSSION

DR. MEES: With regard to the question of artificial silk and static, I should like to remark that artificial silks are of three different kinds, and none of them is nitrate. The electric characteristics of the various rayons are different, and I think all of them are satisfactory for handling film. Practically, the hydrocellulose silks are excellent, partly because they contain a good deal of water and have enough conductivity. They are much better than the old velvets.

MR. TUTTLE: With regard to the electric characteristics of similar materials, I should like to bring up a point concerning some work I did before coming to the Kodak Company. I was studying the contact difference in potential of a film base and a "rubber" of exactly similar material and found that the voltage as measured with the Kelvin electrostatic voltmeter was equally great when different materials were used. There was only a momentary period during which the contact potential difference of similar materials was small. The electric characteristics of the material changed rapidly as it was rubbed. As a result, the fact that you were using similar materials would have no effect.

MR. JENKINS: I have never understood why a proposition made before our Society several years ago has never been adopted. In

place of punching holes in film for signal purposes, why don't we emboss the film at the same place? The embossing of the name in the end of a film has been proposed by Oscar Depue, one of our members, for a number of years. When film so embossed is run through the exit aperture of the upper magazine, the raised characters will open the aperture and make a little light appear.

MR. HUBBARD: I have experimented considerably with photometers and have abandoned this method entirely because you can't correct for color. I have used the Leeds & Northrup instrument and it will not correct for color. An ordinary photometer is only correct to within 25%.

MR. JENKINS: Where we want illumination of known and constant value, we put glass between the aperture and the lamp which allows part of the light to be converged to one side, and this is allowed to fall on a little light-sensitive selenium cell. The rheostat is then adjusted until the cell gives a definite reading.

DR. MEES: If you use a selenium cell, you must remember that it is exclusively sensitive to the extreme red, while the film is sensitive to the blue and Mr. Hubbards' difficulty is accentuated. We color match the lamps to start with and then put them in the printers and photometer them at the same wattage. A small proportion of the lamps must be rejected, which must be done anyway in order not to spoil prints.

MR. CUFFE: It seems strange to me in this day we have to have things on the ends of our reels to wake up the projectionist and things to give signals. I think that if an opaque white film is put in between the end scene and the end title, this can be picked up, and it saves cueing the picture. This is done on the Coast and has proven very satisfactory.

MR. ROSS: I noticed recently that a patent has been issued for a roller operating in the magazine. After the reel has been reduced to a certain diameter, it rings a bell.

MR. TOWNSEND: I find that the best cue is a direct film cue which compels the projectionist to look at the screen part of the time.

DR. ROSENBERGER: In the Rockefeller Institute a continuous projector is used with an automatic stopping device. A sprocket placed before the film window works a mercury pump, so that as soon as this sprocket stops rotating, the mercury goes down by its weight and stops the motor by means of an electric switch.

MR. GREENE: If what is desired is a method to "wake up the operator" there is nothing better, at least with one type of projector, than Mr. Stewart's "quarter system." A few years ago it was my custom to use coins when putting a show together in a hurry when there was scarcely time to take cues. This was with Powers projectors. Later on I tried it on a Simplex—but only once.

MR. RICHARDSON: So far as we know at present there is but one thoroughly reliable, correct procedure in the matter of ascertaining the change-over point and that is by cue taken from the action itself. We do not care to have men "awakened." We demand that the projectionist be before the observation port at all times, watching the effect upon the screen of what has been produced in Hollywood or elsewhere and striving to make it as perfect as is humanly possible. Cue sheets, altered by the exchange, should accompany every production to every theater. That is the correct, sensible procedure, though the projectionist can, and many of them now do, make their own cue sheets.

MR. CUFFE: As far as the cue sheet is concerned, we have done this; the exchanges don't take care of it.

DR. HICKMAN: With the talking movies this will not be necessary because they will have a legend on the side which says: "Operator, wake up."

THE NEEDS OF A TRICK PHOTOGRAPHER

FRED WALLER*

IN ORDER to make the purpose of this paper clear, I will first define "trick photographer." This unfortunately is the nearest term that I know for describing the person in a big studio who is called upon to do the parts of a production which are out of the usual run. In the word "needs" I refer particularly to material, apparatus, etc., besides what is already available and particularly suited for the problems which a trick photographer has to solve.

To give you a clear picture of some of the lines along which improvement is desirable, I will describe briefly the problems encountered in doing some of the trick scenes for the Famous Players-Lasky Corporation.

In a recent picture starring Mr. Meighan it was necessary to show a hail storm destroying the wheat fields in the great Canadian belt. The set called for a road and pathway in foreground, a farmhouse and a barn in the middle distance, and behind this a great expanse of undulating country. In order to slow the movement of the swaying fields and the falling of the miniature hail, a cranking speed of about twelve times normal was necessary, and even though this small set was literally surrounded with lights it was not possible to stop down sufficiently to give the same comparative focal depth as we would have had if the scene really had been made in natural size. Our inability with the ordinary lens to get the foreground, middle distance, and background all reasonably sharp was in my opinion the only thing that might make the audience feel that the scene was not an actual one.

An exterior scene for one of Miss Swanson's pictures called for a horse and rider jumping a chasm sixty feet deep and a second horse throwing his rider down the chasm. Due to weather conditions and time element this set was built entirely in the studio, part in full size and part in miniature. This set was very successful but lacked the final touch of convincing lighting due to the fact that no single source of illumination was available of sufficient power to

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cover the full size portion of the set about 60×100 feet and give a convincing sunlight effect. The miniature, being only about 10×20 feet and 6 feet high, could have been lighted by a single high intensity arc. It was necessary to soften this light, however, to match the lighting on the full size set which had to be from a number of sources. This is an extreme example of the desirability of one very powerful light on a set in order to produce a good sunlight effect. I have made a number of miniature and trick shots, however, that would not require so big a space covered as the instance that I mention, and in which the effect would have been greatly enhanced if such a method of lighting had been available.

There is another feature in existing equipment that causes considerable difficulty and sometimes adds greatly to the length of time and amount of expense needed for making a perfect scene, and that is lamps that flicker or vary in the amount of light produced. This is particularly so in the class of shots known as "Glass Shots" or in miniature shots where several different scales of a set are combined in a single shot. Naturally, under these conditions, if the light on one portion of the set varies, it destroys the desired illusion of being one continuous set.

I have mentioned only three classes of difficulties encountered with existing equipment, and it might seem that they are only optical and electrical. However, if a faster film were available in the first instance a smaller diaphragm could have been used; and in the second instance, the size of a single illuminating source would not have to be so great. If a slow motion camera were available with a longer period of exposure for each frame, the limitations in the first instance would not be so narrow, and to the same degree this would apply to the regular studio camera in the other two cases. In the matter of steadying the arc light for use with miniatures the obvious step of replacing the arc with incandescent lamps is frequently impractical. The heat liberated by large nitrogen lamps causes difficulty with materials used in miniature sets and in the painting of glasses. Even with the use of a fast panchromatic emulsion it is difficult to get enough exposure without too much heat, and the difference in the color value of the lights makes matching a much longer job and visual matching an impossibility. However, I have made a number of shots of this nature in which, due to the necessity of an absolutely uniform light source, panchromatic film and nitrogen lamps have been the only solution, although this usually slows the motions of the actors,

etc., to permit sufficient exposure,—not a good method, as the motion usually becomes unnatural.

It may seem that I have mentioned three things to be desired which everybody has been trying to get for years. There are, however, some points about the work which a trick photographer is called upon to do which allow methods and material to be employed which would not be practical in general production. In the first place, trick shots are entirely a matter of planning, and any arrangements can be made in advance for the use of special film, special methods of development, or special methods of lighting. Most miniature scenes are photographed with a slow motion camera, and a few seconds are all that is necessary in the taking time; therefore, the fact that an arc light of sufficient power might use up its carbons or overheat in half a minute or so would not prevent its use. In the matter of lenses, extreme definition over an entire miniature set is usually not required, as ordinarily miniatures are used to reproduce a storm, earthquake, flood, fire, cyclone, or some similar effect where the details of the action are supplied by close-ups cut into the scene and made with actual sets. Therefore, it is not just a case of expecting a lens designer to do the apparently impossible and make a lens which will photograph at a large aperture and get everything critically sharp from 6 inches to 25 feet, but to find some way of constructing a lens which will give a fair degree of definition over a deeper field. I have seen one lens, recently completed, which indicates a possibility. In it is used an oscillating center element which changes the focal point without changing the size of the image.

This simply serves to indicate the special things which could be done that would greatly assist the trick photographer and allow a reduction in the cost of making these trick scenes and make practical scenes which now are not even attempted. This is particularly pertinent, as miniature sets, glass shots, etc., are very valuable in reducing the present high production costs.

I can think of no group of men so well equipped to solve the problems that arise in production as the members of this Society, and the reason that I chose this subject for a paper was in the hope that it would prompt other men busy in the production end of the industry to go much deeper into the subject of their needs and write papers about them.

DISCUSSION

MR. BAUER: What is meant by the oscillation of the new lens?

MR. WALLER: I don't know in what condition this invention is in the patent office. However, I presume I can tell you what I know without doing any harm. An inventor in conjunction with one of the large optical companies has recently built a lens the center element of which moves slightly forward and backward changing the focal point from the foreground to the background during each exposure, and this little movement averages the focus over a very much deeper field.

MR. RICHARDSON: May I be permitted to direct the attention of Mr. Waller to the hand colored subjects put out by Pathé about twenty years ago? Many of them were in the nature of trick photography, such as diminutive girls dancing in a glass bottle and similar subjects. The subject matter was highly interesting and entertaining and the colors were delightful. I believe Mr. Waller and his colleagues would do well to examine the merits of those old Pathé subjects. I believe they could now be done in natural colors, and that they would be enthusiastically received.

THE STRUCTURE OF THE MOTION PICTURE INDUSTRY

WILLIAM A. JOHNSTON*

THE least understood fact about the motion picture business is, strangely enough, the large and basic one that it is an industrial machine. From manufacturer to consumer it functions exactly like the industries of automobiles, clothing, food products or of any manufactured product. The machine works with regular economic rules and under economic laws.

Most people who, for some reason or another, want to "reform" motion pictures proceed with a conception of the motion picture itself as a great, modern-day agent of education and culture. That is perfectly true. But in order to put a screen picture to-day before the world public, that picture must be created out of raw product, wholesaled to a retailer, and sold by him to the public. From beginning to end it must be, of course, a commercially profitable transaction.

So we will consider the motion picture industry here as an economic machine, its size and structure.

The trade of the motion picture is world wide. The American industry is built upon a world market. In this respect it is somewhat unique among American industries. From its very inception its export trade has been a foremost consideration. We shall discuss the foreign field later in this article.

The American industry consists of three economic divisions:

- (1) The producer, or manufacturer
- (2) The distributor, or wholesaler
- (3) The exhibitor, or retailer

First a few fiscal statistics, and then we will proceed to a discussion of each of these industrial divisions.

Some Fiscal Facts

The total investment in the American industry is approximately a billion and a half dollars. Of this amount the investment in 15,000 theaters is about a billion and a quarter; in studios and distribution offices, about two hundred and fifty millions.

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To-day upwards of 7,000,000 persons attend daily the motion picture theaters of the United States. This would indicate an appeal to at least 50% of the population. With many families the expenditure for motion pictures is a considerable, if unknown, part of the yearly budget. The fact is that the motion picture has become quite generally a necessity, though paid for somewhat loosely, like a luxury.

The average price of picture-theater admissions is around twenty-eight cents. In the larger cities it will average about thirty-five cents. We can figure, then, on a daily box-office intake in this country of \$2,000,000. Taking into consideration those states and localities where theaters are closed on Sundays, we can figure a yearly total for the picture-theater box office of approximately \$650,000,000. This is for the United States and Canada only. The total theaters throughout the world exceed a billion dollars a year. The American producer supplies at least 85% of the pictures shown in the theaters of all foreign countries.

Production

The center of production to-day is Hollywood, California and it has been for a number of years. Sunlight and scenery attracted here the pioneer producers. These advantages are not such pronounced factors to-day. Florida, for example, has both. But the production industry has become settled in California and around it have been established studio supplies of all kinds, labor, facilities and, of course, the important element of professional talent. A small army of extras exists, and another of "types," well organized, card-indexed, and immediately available. From these ranks new and promising players are constantly being recruited, a very important consideration in picture production for two reasons: first, that the public is hungry for new and vivid personalities; and, second, that a limited supply of featured players makes salaries rise to a point at which production profits are jeopardized.

The cost of the average picture (feature) is divided as follows taking the production dollar as a basis:

Actors' salaries	\$0.25
Directors, cameramen and assistants	0.10
Scenarios and stories	0.10
Sets (manufactured)	0.19
Studio overhead (including cutting, assembling and titling of film)	0.20

Costumes, gowns, etc.	0.03
Locations (rent of grounds and properties and transportation)	0.08
Raw film	0.05
	<hr/>
	\$1.00

Stars' salaries, it is evident, constitute a large part of the cost budget. Delays, therefore, in "shooting" the picture are expensive. Even a few weeks' overtime may make a picture unprofitable. Hence, everything that contributes to the regular progress of so many scenes per day is highly desirable.

In these competitive days of high cost production, the secret of success would seem to be the careful blue-printing of the picture in advance of the "shooting" or actual studio work where the heavy expenses begin. By blue-printing is meant the transference of the story to its details of picturization and the laying out on paper of the several hundred scenes, indoor and outdoor, in an exact sequence of so many a day.

A number of elements conspire to make production costly and hazardous: weather conditions (if there are outdoor scenes or "locations"), illness of the principals, accidents, inadequate studios, etc. Many visitors at Hollywood marvel at the extensive ground space of the large studio plants. As a matter of fact, expensive as the land is, it pays the large producing companies to have plenty of stage floor space so that there will be no delays while heavy payrolls are going on.

The high salaries paid to stars and featured players have, for some time, created more or less of a public sensation. Most people have simply wondered or doubted; others of a more practical mind have arrived at the conclusion that a business so prodigal should be heavily taxed.

The plain fact is that the price paid for a star's name and services is a hard and fast result of the law of supply and demand. The price of radium is fixed in exactly the same way.

The public wants the stars and will pay several million dollars, we will say roughly, at the box-office. This, the producer figures, will enable him to pay a high salary and still make a profit. Given a number of producers competing sharply and all figuring to the limit, just as contractors in all lines do, the salary goes up. The fact that it reaches a figure unprecedented in the show world is simply due to the other fact that the volume of business which the motion picture does

is also unprecedented in entertainment annals. The famous stars to-day have even gone beyond the producer competition stage; which is also economic. They did some figuring too and decided to be their own producers. They are now in business for themselves.

In the earlier days of feature production there were many producers. To-day the business is largely consolidated, and the large, modern studio plant is a complex affair of many departments and heavy current expense.

The most recently built studio in Hollywood cost \$2,000,000 and comprises twenty-three buildings with over 350,000 feet of floor space. In addition are bungalows, sheds, and minor buildings. A large administration building houses the production chiefs, the supervisors, directors, writers, business, and casting offices. To the rear are the carpenter, metal, and plaster shops, dressing rooms, property and wardrobe departments. Then the large stages themselves, and about them open spaces with streets and a variety of structures for outdoor "locations." The streets are concrete paved. Forty-eight acres of land are utilized.

The stages, measuring 240 by 135 feet, are equipped with great overhead tramways for handling the arc and mercury vapor lights; the floors are heavy enough to support trucks.

The electrical plant has space for twelve huge generators. Twenty billion candle-power is available, sufficient current to supply a city of 10,000 population.

Other buildings are: a large one, housing film cutting and projection rooms and camera vaults; a garage, 40 by 100 feet in area; lumber sheds, saw and planing mills; a large incinerator; scene docks; a studio greenhouse 40 by 100 feet.

In the building of the plant 150 carloads of lumber were used, also three carloads of steel sash, 50,000 square feet of glass, six miles of underground conduit, and twenty miles of lighting wire.

With reference to running expenses I may refer to another studio where the budget runs around \$400,000.00 a week.

The present production régime may be judged by the fact that one studio has under contract at high salaries the following creative staff: seventy-one writers, thirty-one directors, and forty-nine stars and featured players.

The product of the industry may be divided into two kinds: long and short subjects.

Long subjects comprise the so-called feature photoplays of five

reels or more in length. Short subjects, limited to two reels, consist of comedies, news reels, cartoons, travelogues, and novelties of various kinds. Producers, for the most part, specialize in either of these two fields of work.

Each year over 700 feature photoplays are produced. The production cost varies all the way from five thousand to over a million dollars per picture. These are the extremes. So-called "western" dramas, consisting largely of out-door settings, cost generally from \$10,000 to \$60,000. Program features in general cost from \$60,000 to over \$200,000.

The production side of the industry is quite similar, in an economic way, to stage production. It is, in other words, the show business. But, as soon as positive prints of the motion picture show (the negative) are made and the films go into the cans, the business enters a regular industrial phase. And so we proceed to a consideration of distribution.

Distribution

Distribution has two functions: (1) physical distribution, involving shipping, clerical work, collections, and the inspection and renovation of the film; and (2) selling and advertising, getting the contracts for groups of pictures and then play dates for the individual picture. Further, there are two methods of general distribution in vogue. The first, which is used by all the major concerns handling feature photodramas or short subjects or both, is conducted through branch offices owned by each company and located at key points throughout the country. The second method is called "state rights." Under this plan, the country is divided into specific territories in which individuals—"buyers" as they are termed—have their own distribution offices. They purchase rights to pictures for their local territories for a flat sum or on a percentage arrangement from independent producers or distributors located in New York whose business it is to handle the sale of rights for the producer.

National distribution by the major concerns comprehends a structure highly organized and functioning in more than thirty cities or strategic points: New York, Boston, Philadelphia, Washington, Pittsburgh, Indianapolis, Cleveland, Detroit, Chicago, Cincinnati, St. Louis, Kansas City, Memphis, Atlanta, Charlotte, New Orleans, Dallas, Denver, Salt Lake City, Des Moines, Omaha, Los Angeles, San Francisco, Minneapolis, Butte, Seattle, Portland, Oregon, with sub-offices in several other lesser towns. These offices are termed

exchanges. They are the arteries of commerce of the film industry. From them the picture moves to the theater on its way from studio and laboratory to the public; it comes back to them after exhibition, and takes up its journey again to other theaters, until the life of the picture is over at the end of two years.

Physical distribution is a rather complicated affair, but its main out-lines are simple enough. The studio, having completed the picture sends the negative to the laboratory, where positive prints are made, probably a hundred for each average production; two hundred or more for photoplays of outstanding excellence. The prints are shipped, under allotment and instructions from distribution headquarters in New York, to the company's various exchanges, where they are booked to the theaters.

The administration of the exchange is under the direction of a branch manager, who, in turn, reports to his chief at the home office, the latter being known as general manager of distribution or sales manager for the entire country.

The prints go out to the first-run theaters for a stated number of exhibition days arranged by contract and then travel to the second-, third-, and fourth-run houses. In direct charge of the handling of the film is the booker in the exchange, who must see that the print gets to the given theater on time and in good condition, and that it gets back promptly so that it can take up the next stage of its journey.

Transactions with very few exceptions are cash. The theater pays in advance or meets a c. o. d. on the film when it is delivered and also pays express or parcel post charges both ways. Thus the national distributor is enabled to realize a comparatively quick turnover on his product.

The exchange also attends to film inspection and renovation; and in cases where the print wears out before its natural life ends, places a new print in circulation, thus permitting the theaters to give the public satisfactory results on the screen.

Until late years, the attention paid to the condition of prints was extremely scant. But this evil is by way of being remedied, not only through more efficient work at the exchange, but by more care on the part of the theater while the film is in its possession.

But the physical side of the film is by no means the only concern of the exchange, nor is it the most important. Greater emphasis is placed on the selling of pictures to the theaters, though "selling" is really a misnomer; "renting" is the proper term.

A motion picture is an affair of copyright; what the theaters actually do is to pay royalties for exhibition rights.

The exchange manager then directs his group of salesmen in their salesmanship work with exhibitors. There being no fixed price for film, the thing resolves itself into a typical buyer-seller situation, with the legal doctrine of *caveat emptor* fully operative. I speak now of the renting of pictures to theaters individually owned. Large circuits are generally "sold" direct from headquarters, because of the greater importance of the sale.

The contractual relation between theater and distributor has many ramifications, which go to the heart of the economics of the picture industry:

(1) Theaters sign contracts for pictures at certain seasons of the year; roughly, in the spring and fall. The theatrical year runs from September to September. Contracts are made for the year or half-year and usually for pictures "in block;" that is to say, for a whole group of twenty-five or more productions rather than singly. This practice applies equally to feature photodramas and short subjects (comedies, scenics, educational, news reels, etc.).

(2) Save in rare instances, contracts, obtained by salesmen from theater owners, are not in force until they are signed and approved by a official at company headquarters and are subject to cancellation by the theater only on very unusual occasions.

(3) Price is determined, as above stated, by bargaining and cannot be changed once it is written in the contract unless the theater loses heavily on the exhibition of a picture or a series of pictures, in which case the distributor may make an adjustment.

(4) Disputes arising between buyer and seller are arbitrated. This is compulsory under the contract.

Arbitration boards, composed of equal representation of exhibitors and exchangemen with a seventh arbitrator subject to appointment in the event of deadlock operate in all the key cities and have been remarkably successful in stabilizing the industry's economic structure. Thousands of cases are settled each year and resort to the courts is practically unknown. This arbitration system is, of course, not yet perfect, but it is a big advance over the economic chaos of the industry's early days and has attracted wide attention in many quarters of the business world.

Each large distributing company—there are about twelve of these, to which should be added a similar number for distributors

selling "state rights" on a national scale—maintains a considerable sales force, and the whole distribution operation is under the executive direction of the sales chief in New York. He must have his finger on the pulse of the market at all times, and this necessitates extensive trips through the various territories. He determines, to a large degree, sales methods and prices and maps out, in collaboration with his home office advertising department, and his production associates, the nature of advertising to be used, the expenditures, and where advertising is to be placed.

The advertising of motion pictures is divided as follows:

- (1) To the theaters through the trade papers.
- (2) To the public, via national magazines, newspapers, and posters and other accessories.

In general, it may be said that advertising in the film industry is a distinct function of the distribution department. The handling of posters and accessories is a large item. Various types of "paper," as posters are technically termed, are issued on each picture, then delivered to the exchanges, and by them sold to the theaters at nominal prices.

The intake to all distributors from film rentals runs, in the course of a year to approximately \$185,000,000. And of this figure, it is safe to say 30-40% is expended for distribution overhead.

With very few exceptions, large distributors are now also engaged in exhibition through direct ownership or affiliation with theaters and theater circuits, the play-houses thus controlled now being about 1800. In comparison with the total—some 15,000—this group is numerically small, but it includes the finest theaters and therefore the largest single purchasing power in the exhibition field.

Exhibition

In all the amazing growth of the motion picture industry, no branch of it has shown greater progress than that of its theaters.

In the first days of the picture house, the show places of the large cities and the small towns were pretty much alike.

This was the store show era so familiar to all but the younger generation. There was little investment on the part of the theater men themselves for a variety of reasons, chief among which was the lack of finances or the ability to secure them, the want of vision to see the motion picture's permanent popularity with the public, and the small admission charge of five or ten cents that did not permit

the average theater owner to realize enough net profit quickly to improve the size, convenience or sumptuousness of his house. True it is that many of the fortunes that have been made in the movie theater had their foundation in the five-cent show, but of the twenty thousand places of amusement that had sprung into existence by 1914, it is safe to say that a very small percentage were really making money. There are seven thousand towns in the United States of less than 1500 population that during that period and most of the time since, up to the last two years, had some kind of a movie show. Ninety percent of this class had never made anything more than a precarious living, and in no small number of instances the show has over the years shown an actual loss. Since 5000 of them or their successors still remain in business, up to this time there always have been optimistic newcomers to take the place of those who finally reached the end of their means or grew discouraged over their lack of success. On the other hand, some facts and figures are available that would permit a guess that this class of house is greatly on the wane.

In certain states, and in every case such state is one where good roads have been built, the shrinkage in small-town theaters runs as high as 35%. In New Jersey, a state that has unusually good roads and also possesses a large number of medium sized cities, there remain only twenty-nine towns of the class mentioned that support a picture show even one night per week. Several of these are summer resorts where the transient population over a portion of the year is many times greater than the total permanent population. It is true, however, that New Jersey is an exceptional territory in this connection.

In Kansas there are still 241 of these "opera houses" out of a total of 428 theaters in the state. It may rightly be argued that a goodly portion of these will remain, since Kansas roads are none too good, its large towns are few and far between and its small towns numerous and progressive for their size. With the exception of North Carolina, practically all the Southern states are in a like condition. Great strides, however, have been made in many sections of the South in theater construction, notably by two large circuits, and some shrinkage may be expected as a consequence.

It is not to be construed from this recital that the motion picture is losing its popularity with the public. In fact the contrary is quite the case. The picture-going public is simply concentrating its patronage in the larger towns, where new and better theaters have been provided for them. It is also a fact that the number of seats available

are greater than ever. It is just that these seats are placed in a smaller number of theaters.

Changing Theater Concepts

Roughly speaking, the history of the picture theater may be divided into three parts. The first was the store shows which were superseded by larger and more comfortable but still inexpensive theaters. The picture house of 1914 that cost above \$50,000 was the exception, taking the country by and large. A house that cost five thousand dollars in a town of five thousand population was considered quite good enough and perhaps better than the village could afford. Capital still declined to invest or loan money for theater construction even where the theater manager had lived down the early distrust for his kind. Getting the funds together to build a theater costing as little as the sums mentioned above was a hard job—harder than obtaining the capital for the million dollar palace of to-day.

Where the five-thousand-population man had to borrow from his friends, relatives, and neighbors to build his modest theater, he can now get twenty times that amount from his banker for his latest venture. The reason for this change of heart on the part of the money people is not readily apparent, nor would the same set of facts hold good for all towns. Perhaps one of the basic reasons is that the theater owner has earned his place in the sun, such of the old crowd that still remain, and certainly, as the business has grown more stable and, if we may be allowed to use the word, respectable, new and better business men have been attracted to it.

This new element has brought capital with them, where the first men had little or none. They have been able to go to the banker on a business basis and on a scale that commanded the respect of those who have money to loan. Then, too, it became apparent that a good theater was a decided asset to a town. Local banks have directors chosen from local business men. It is not beyond the realm of possibility that many a bank director has voted to loan on the proposed new theater with one part of his mind sticking strictly to banking principles (reputation and security) and the other wandering across the street to his own particular enterprise.

The financing of large theaters is, of course, in its latest development an entirely different matter. Wall Street has discovered that the public is willing to buy stocks and bonds in picture ventures. Abundant capital is now available for the kind of theaters that the

public demands and in the public demand lies the complete success or failure of the picture theater.

When it is remembered that one picture in one theater can play to \$400,000 (record of *Variety* at the Rialto Theater, New York City) not simply because it is an out of the ordinary production, but also because it is shown with proper surroundings, the importance of providing those surroundings may be readily understood.

The number of really big and expensive theaters that may be soundly financed is relatively small, however, compared to the number of theaters, about 15,000, now existing in the United States. There are seventy-nine cities with populations of over 100,000 where some 500 houses of the "million dollar" type have been constructed, and probably as many more of just a slighter less expensive and luxurious grade are contained in the next group of cities, say down to 50,000 population. The question of how many of this class of house can be profitably operated is something that even the best informed cannot answer. An expert gesser predicts that Kansas City, for instance, will support seventeen or eighteen houses, most of which should be situated in residential sections. These theaters will do all the business and more than is now divided among fifty-nine houses. In other words, for every new type house built, provided it is properly located and conducted, three of the old type will be forced out of business. Facts to substantiate such predictions are to be found in such instances as the opening of the Eastman Theater of Rochester, New York, where nine smaller houses closed their doors very soon thereafter.

Attendance Figures

The attendance figures at picture theaters for the larger cities have reached amazing proportions. Forty-seven million people attend the picture theaters every week and twenty-four million of these do so at 3300 houses, large and small, in the seventy-nine cities of 100,000 population or over. Big city first-run picture palaces fill their seats as high as eighteen times per week. An average for the thousand houses mentioned as the best in the country would probably be twelve times per week. Figuring the average seating capacity of these theaters as 1200, which is a close guess, seven million people weekly are entertained in these houses alone.

This ratio of attendance is not to be applied to all the theaters of the country, however. To illustrate, accurate figures compiled for the average house in a town of less than 1500 population show the

weekly attendance to be 350 people. It may be explained in this connection that most of the movies in these towns are open but two nights per week and many of them only once. The same table of figures gives the average attendance in a town of 5000 as 3800 and in a city of 25,000 as 14,800.

Foreign Distribution

The American industry, as is well known, has been supplying for the past several years about 85% of the picture needs of all foreign countries. From almost the beginning of the industry, foreign sales have been a matter of considerable importance, but they have grown steadily until now they represent fully 40% of the American producer's gross income.

The American producer, because of his large domestic market, has been able to put a lot of money into his pictures. The foreign producer, lacking our large market over here, has been correspondingly cramped. I believe also that there is an important psychological reason for the American producer's success. This is a new country with few or no literary traditions. Secondly, we have here a polyglot population and have acquired valuable experience in producing for such a mixed people as against the European producer's necessity of catering to people not only of one type but also with old and firmly established taste in the matter of stories.

Just how long this predominance of the world's picture markets by the American producer will prevail, however, is open to conjecture. Foreign governments are taking a hand in the matter. They realize that the motion picture to-day is a great advertiser; in other words, that trade now follows the film instead of the flag. They are insisting upon increased home production and adopting such regulatory measures as will call for the exhibition of a quota of their own pictures to ours. Production is going ahead on quite a scale in Germany; Great Britain is beginning to build large studios, and France is already supplying about fifty features a year.

On a trip abroad last spring I found that German made pictures in Germany and French made pictures in France were grossing rentals several times greater than our program features. I also found in France that nearly half of the pictures shown in the theaters at that time were of French origin—this due to the fact that in the ordinary program picture the Continental countries of Europe much prefer their own stories. This is not true of Great Britain or so true of

Germany as of France, Spain, Italy and other Latin countries. The situation, however, raises a serious question. It is possible that with the development of production abroad we will have to rely for our foreign trade upon our specials rather than our program pictures.

One by one the leading American distributors have built up their distribution machines in the foreign field. A leading American distributor has in its foreign division one hundred and ten offices and exchanges scattered throughout seventy countries and employing eighteen hundred persons. Thirty-seven languages are used and titles and advertising matter must be prepared in all of them. In Arabia, Egypt, and Turkey two and three languages are used on each film. This, together with the fact that each country has its own particular rate of exchange of money (some of them still unstable), complicates the conduct of the department enormously.

All of these offices must be supplied with prints and sales material. One negative of each picture is shipped abroad, from which prints for England and certain Continental nations are made, and in addition to this, about 500,000 feet of positive are shipped out each week from America, not including West Coast shipments. Advertising matter, press books, posters, publicity stories and cuts, newspaper ads, and other exploitation material must be supplied on each picture in every country. Special exploitation men are stationed at exchanges in Mexico, France, England, Germany, Australia, Argentina, Italy, and Japan. Foreign offices are approximately four to ten months behind United States release dates.

SOME PSYCHOLOGICAL ASPECTS OF NATURAL COLOR MOTION PICTURES

L. T. TROLAND*

PSYCHOLOGY is not ordinarily considered to be an engineering subject. This is due, however, not to any lack of technical and practical problems of a psychological nature but rather to the relatively undeveloped condition of psychological science. Nevertheless, we are beginning to see signs of a psychological technology in many fields of human endeavor, not the least of which is the production and manufacture of motion pictures.

If we regard the motion picture art from the standpoint of the director, its basis is obviously almost wholly psychological. The function of motion pictures appears to be to stimulate the emotions of an audience, and the director is successful in so far as he accomplishes this result in a not too disagreeable manner. In his efforts the director is endeavoring to control the emotional reactions of the average motion picture patron, who is said to have a mental age of approximately twelve years. He is also compelled to manipulate the motions and emotions of his actors, a task which is also not free from psychological problems.

From the standpoint of the producer the big problem is always that of the psychology of the common people as expressed in the familiar phrase, "What does the public want?" Undoubtedly the producers would pay millions to any psychologist who could answer this question infallibly. It is evident that producers have only a vague idea of what the public wants at any given time, the most reliable principle being that the public will like something which is very different from anything which it has ever seen before.

When we turn our attention to the action of the photographic and optical media through which the producers and directors must express their ideas we find a very complex array of psychological problems. The stroboscopic phenomenon upon which the motion picture is founded is a purely psychological effect. Thousands of pages have been written in psychological publications concerning the conditions

* Technicolor Motion Picture Corp., Boston, Mass.

and explanation of this phenomenon. If we dig a little deeper still, we find that the gradations of brilliance or apparent light and shade which are presented to the motion picture audience are psychological reactions. As Mr. Jones has recognized with his characteristic thoroughness, the complete theory of photographic tone reproduction necessarily involves the sensibility curve of the eye as a final phase.

Now the perfection with which the screen image reproduces the original scene is evidently very incomplete in current motion picture work. There are a series of very interesting psychological questions which may be asked as to the *desirability* of true perfection in this regard.

Is it desirable that the movies should become audible, as in Movietone, Vitaphone, or Phonofilm?

Is it desirable that they should present three-dimensional plasticity, as in recent experiments?

Is it desirable that they should show the natural colors or hue and saturation aspects of the scene, permit me to say, as in Technicolor?

In a word, is it desirable that they should lose their peculiar movie characteristics and become identical in effect with reality or the best in drama?

I shall not attempt in the present paper to answer all of these questions, although it seems likely that the failure of motion pictures to *recreate reality* is at no point an actual advantage except from the economic standpoint. However, the technique of motion picture reproduction *does* permit many effects, such as rapid changes of scene and viewpoint, which cannot be duplicated on the stage. A glorified motion picture having no limitations would be far less limited than is theatrical production at its highest point. I must confine myself in the present paper primarily to the last of the specific questions which I have enumerated; namely, that of the desirability and other psychological aspects of natural colors on the motion picture screen.

Financiers and engineers who have spent money and time in the attempt to make possible motion pictures in natural colors have done so on the assumption that there would be a strong demand for such a product. When it was impossible to manufacture such pictures, very few people seemed to doubt their desirability. However, now that it has become possible to produce motion pictures in substantially natural colors there seems to be an expression of skepticism on this particular point. I may refer to comments to this effect in a paper¹

¹ "An Exhibitors Problems in 1926," Trans. S.M.P.E., Vol X., No. 27, p. 47-48, (1926).

presented before this society by Mr. Eric T. Clarke. He considers that the number of persons in the average motion picture audience who are interested in color as such is too small to be considered." He says, "To the exhibitor, color at present is no talking point," and thinks that the shorter a color insert, the better it is. Among producers and directors we find a wide range of opinions—from those who see no advantage in color to others who are highly enthusiastic about it. One of the commonest propositions is that color interferes with the appreciation of dramatic action.

I am far from believing that it is possible to arrive at a conclusive opinion regarding the value of color, upon a wholly theoretical basis. To be *sure* of this question we must work it out in practice. Nevertheless, the arguments against color are just about as academic as those in favor of it, so that something should be said on the latter side and there is a great deal to be said, the foundations for which seem rather secure.

Of course, we must recognize that there is an *economic* as well as a psychological problem. We must first show that natural color in motion pictures has *utility* in the economic sense. Such utility rests upon the psychological effect in the minds of motion picture audiences, in the enhancement of the entertainment value of the pictures. In endeavoring to demonstrate the existence of such a utility we may appeal to practical evidence or to fundamental psychological principles, the latter, of course, being based upon empirical observations in related fields. However, as a second point, it is of course necessary that the *increased cost* of natural color should not exceed the added utility, and it is obviously a technical and business problem to reduce the cost to the point where these two factors are in equilibrium. Assuming that the cost can be reduced so as to be less than the utility, then the success of the project is inevitable in time, although it will meet with temporary resistance due to prejudice and habit. However, we may simplify our present discussion by assuming that motion pictures in natural colors ultimately can be produced at the same cost as in black and white. We might then ask whether they would be used and to what extent; and even whether there would be any reason why they should not entirely replace black and white. If we believe what some critics say, we might still doubt whether they would be universally or even partially adopted. It is my purpose to examine the probable truth of such ideas.

We may consider first a proposition which seems to be enter-

tained to some degree by certain motion picture directors and which I will formulate in extreme form. Let us assume that the function of the motion picture is identical with that of literature, as represented for example, in the *novel*. In this respect the motion picture is not intended to be a *representation* or *reproduction* of anything, but is simply a medium for arousing certain ideas or meanings in the mind of the witness. The print in a novel has no resemblance to the thing referred to, but when we peruse the novel, images or meanings are aroused which form a connected story and result in pleasure. In accordance with this theory the sole advantage of a motion picture over a written story lies in its *greater efficiency*. It suggests the story or sequence of ideas far more *rapidly* and with *less effort* and fatigue on the part of the audience than does the printed volume. "The Three Musketeers" can be conveyed on the screen in three hours, whereas it might take three full days to get the story from the text of Dumas. Moreover, the chances are that the screen presentation gives more detail than does the written one.

If we think in harmony with this assumption, a screen story might consist entirely of titles which tell the whole tale provided it were possible to cram all of the ideas required into the same length of film which is used in the form of pictures. The only defect of the printed symbolism would lie in its slowness and general inefficiency. However, we may note in passing that the pictorial method is evidently inadequate at some points, since it is usually necessary to supplement it with titles, which represent the literary method.

Now let us suppose that the function of the motion picture actually *is* limited to story-telling in the manner above suggested although at the same time the medium is one of pictures rather than of words. *To what extent is the story-telling capacity of the picture impoverished by the absence of natural color?* One way of attacking this problem would be to examine a large number of novels and determine to what extent either direct or indirect references are made to color. It is evident that without the use of titles, black and white motion pictures can convey no color impression whatsoever, although the novelist has as great a freedom with color as he has with any other ideas. Thus, if the story writer is describing a landscape or the appearance of one of his characters he is entirely free to introduce chromatic ideas, but in black and white motion pictures this is wholly impossible. The greenness of vegetation, the blueness of skies, the red of a rose, or the bloom on the heroine's cheeks are entirely debarred from the

black and white story. Of course, we can introduce a title which says that the heroine's cheeks are rosy and her lips ruby, but in practice this does not seem to be done.

Now there is no doubt whatsoever that we should be compelled to delete a considerable portion of descriptive matter in a story if we were to limit its power of suggestion in the manner above indicated, so that it would be, so to speak, a strictly *black and white story*. We should be required to expunge not only direct color references but also all indirect references; for example, we could not even say that the woodland scene or the heroine is "*beautiful*," since a very large fraction of the beauty in such cases consists in the nature and distribution of colors. Instead of saying that the heroine is beautiful, we should be compelled to say that she exhibits a pleasing contour and distribution of lights and shades. I do not know whether I can get some student of psychology to make a statistical study of 100 novels in order to arrive at a solution of the above problem, but it is evidently a possible subject for a thesis.

It is my personal conviction that the story-telling power of a film is distinctly and unpleasantly curtailed by the absence of color, so that even on the basis of the most reduced conception of what the motion picture is for, we can claim that natural colors should bring a very definite enhancement of utility.

Let us, however, go back to our assumption of a superscreen story made up entirely of titles and yet conveying with equal efficiency all of the ideas which would be conveyed by a pictured presentation. I believe we can recognize immediately that such a presentation would not have the entertainment value of the picture film. If this is so it means that there are some other features about the picture films which, compared with a written account, *do* add to their entertainment value. One aspect of this sort might be formulated in terms of increased *realism*. The picture is far more convincing than the written story because it approximates more closely the actual objects and events to which the story refers. The associative processes by which we pass from symbolism to meanings are greatly reduced. Now I believe that it is a psychological truth that the arousal of interest and emotion depends always upon some degree of *conviction*. A mere idea is not sufficient; it must be "*believed in*." The actual experiences of every day life are usually entirely convincing because they are direct appeals to sense, whereas the majority of the things which we read or hear about are unimpressive because we always doubt their existence to

some extent. The same reaction applies, of course, to pictures but to a less degree according as the pictures become more and more faithful to our conception of the reality. Thus a photograph is much more convincing than an artist's drawing.

Once we are embarked on this line of thought it is impossible to avoid accepting natural color. Mere black and white reproduction is radically lacking in faithfulness of representation. It reduces all observers to the level of absolute color blindness, which is a very rare condition. A motion picture audience is arbitrarily afflicted with this ocular disease and is subject to a corresponding impoverishment of perception. When we divorce ourselves from our habitual familiarity with this defect of the motion picture we realize at once how imperfect and symbolic the black and white motion picture representation is. How would we feel in real life if all objects were presented in colorless shades or grays? How peculiar familiar scenes and faces would appear!

This theoretical consideration is certainly substantiated by an *appeal to the facts* regarding color motion pictures as compared with those in black and white. After viewing a sequence of scenes in color, the black and white pictures give an impression of unnaturalness and weirdness which is highly disagreeable. The loss of reality constitutes a very definite step-down of interest and emotional appeal. I should maintain that this reaction is not an artificial one but merely results from a removal of the defence which is ordinarily made against the artificiality of the black and white representation.

Now, it is evident that realism and story-telling are closely related, so that the dramatic effect of the picture should be greatly enhanced by natural color. In spite of this evident truth, we find, as noted above, that many producers and directors feel that the use of color interferes with the appreciation of dramatic action. They imagine that the audience will look at the color and have its attention distracted from the story or ideas which the picture is supposed to suggest. It is possible that some effect of this sort really may be experienced when we make a sudden change from black and white to color, as in the case of a natural color insert in a black and white subject because of the habituation of the motion picture patron to *chiaroscuro*. However, even under these circumstances it can be presumed safely that the distraction of attention results from the pleasantness or entertainment value of color *per se*, and hence we might argue that temporarily the dramatic action might be suspended

without any net loss of interest. Directors are accustomed to think about the subtleties of their work and they should be careful not to confuse effects. If a picture is shown of a woman in a gorgeous costume or with beautiful jewels, the audience should be given some time to appreciate this display before the story proceeds. This is what would be done in a theatrical presentation, and theatrical producers evidently do not feel that gorgeous costumes are detrimental to box office receipts. In other words, the use of color *does* change the requirements made upon the director, although it would seem that in general it makes it easier for him to produce a pleasing film. We have seen a number of short subjects in color succeed where the same subjects in black and white would certainly have had little appeal.

I believe that the alleged disturbances of attention due to color are greater in the minds of experts, such as motion picture directors and producers, than they are in those of the average motion picture audience. We have met several laymen who witnessed "The Black Pirate" or other color productions without explicitly recognizing the existence of the color. This does not necessarily mean that they did not enjoy the picture more because the color was there, but its presence certainly did not distract them. The novelty effect, when it is present, quickly wears off. If natural color as such interferes on general principles with dramatic appreciation, then the legitimate theater should produce its plays in black and white, not even permitting flesh tints to appear on the faces of the actors. Instead of doing this the colors used on the stage are of a supersaturated variety, evidently because the glare or yellowness of the foot-lights desaturates the normal colors and these have to be restored to prevent the audience from getting an unnatural reaction. It has even been stated² that motion picture *actors* cannot perform satisfactorily in a black and white set, so that it has been found necessary to go to the expense and inconvenience of using normal colors in the studio. But incidentally the black and white camera rejects all of this beauty except in so far as it affects the pantomime.

Now the added realism which is attainable with natural color film as compared with black and white is no mere logical deduction. The effect, of course, varies with the character of the scene, but certain types of scenes are enhanced in a startling manner by the

² "Panchromatic Negative Film for Motion Pictures," by Lloyd A. Jones and J. I. Crabtree, Trans, S.M.P.E., Vol. X., 27, p. 163, (1926).

use of natural color. An element of *atmosphere* may be introduced which is unobtainable in any other way. A very striking example of this is in the case of water scenes, particularly where there are waves or surf, when one frequently gets such a vivid impression that he can almost feel the coolness and freshness of the sea air. Color and the impression of *depth* or distance in pictures are well known to be closely associated, and seascapes or landscapes in color are very appreciably more stereoscopic than in black and white. Of course we cannot expect to get a full stereoscopic effect without making use of the binocular principle, but in many cases the so-called secondary criteria of distance exert a very powerful influence. Among these are to be found the effect of atmospheric haze upon colors. This haze in itself usually has a light bluish tint, and it reduces the saturations of colors in proportion to their distance. This effect is lost in a black and white reproduction.

Another important case in which color adds realism is one which is practically universal in motion pictures. This consists in showing *flesh tints* in their normal hues and saturations. It is needless to say that proper rendering of flesh tints is a primary requisite of any color process, whether it uses the two or three-color principle. In practice it is not difficult to get theoretically perfect flesh values on a two-color basis; in fact, it is much easier technically than in the case of a three-color system. Of course, there are many different flesh tints, ranging from the darkest negroid to the palest Caucasian, and this variation of flesh color is by no means without bearing upon the story-telling aspect of the pictures. The black and white picture is powerless to show the significant difference between the deep bronze tan of a rough outdoor character and the delicate bloom of the ideal heroine's cheeks. It cannot show a man either as red-faced or as "getting red in the face." The fact that we can witness a motion picture presentation without being positively annoyed by the imperfection and unnaturalness of black and white flesh values bears witness to the extent to which mental adaptation is possible. Undoubtedly our familiarity with black and white photography, in general, helps in this adaptation, but only a brief experience with a good color rendition is required to break it down.

Undoubtedly the greatest "kick" of color, at least for the male members of an audience, consists in the value which it adds to the delineation of feminine beauty. All pretty girls in black and white are pale and consumptive. In the color film they look as we like to see

them in every day life or, even better, on the stage. I do not know to what extent it is moral to advocate the cause of colored motion pictures on the ground that color adds to "sex appeal." However, there is a considerable use of this sort of appeal in motion pictures; to such an extent that I believe the appeal in question has been designated as "it" in this domain. Miss Clara Bow, as the great exemplar of "it," loses entirely her famous auburn colored locks when delineated by the black and white camera, in spite of which the press agents continue to include this feature among her many other pleasing attributes. One well known director hails the advent of commercial colored motion pictures by saying that they "bring sex into the movies," which seems to imply that this factor was absent hitherto. I cannot vouch for the truth of this implication, but at any rate it is evident that natural flesh values are of tremendous assistance in this particular matter. Of course, the censors might frown upon the advocacy of color on this basis, but as a psychologist I feel quite sure that the point is a very important one, because all experts admit that the basic appeal of motion pictures must be through primitive emotions, among which eroticism is not the least.

This leads us to consider another fundamental question, namely to what extent the motion picture should be supposed to constitute "a thing of beauty" in itself or to entertain because it is inherently pleasing to look at. Now there is no doubt that a great deal of pleasure can be derived from the mere looking at *pictures* even when there is no particular continuity or story involved. It is much more entertaining to go through a pile of photographs, no matter what their subject matter, than to sit and do nothing; and I think that no one will disagree with the proposition that pictures are much more interesting in themselves if they are in natural colors. If we study the history and practice of the graphic arts, we find that artists have almost universally preferred color to black and white in spite of the much greater difficulty and cost of the chromatic medium. Of course, there are some domains of art which are hardly amenable to color, such as sculpture and, apparently, up to recent times, photography.

I have found that almost every ordinary person prefers a color still photograph to a black and white one even when the colors are quite crude. The objection to color photography, whether for the amateur or the professional, lies in its difficulty and expense rather than any aversion to the product. Apparently no really commercial method of producing natural color photographs on paper

has yet appeared, but wealthy patrons frequently pay exorbitant sums to experts to obtain color portraits of themselves or their friends.

Now the same situation has apparently obtained in the motion picture field up to recent times. There has been no color process which has been capable of yielding reasonably good reproduction of natural colors and at the same time did not have insuperable defects of a practical or economic nature. However, the Technicolor process in its present form overcomes all of these objections with the possible exception of a reasonable increase in cost. Technicolor cameras are now able to work under exactly the same lighting conditions with exactly the same lens apertures as do black and white cameras, and Technicolor I. B. film has the same mechanical characteristics as black and white film. It is single-coated, runs through any standard projector, and shows greater resistance to mechanical breakdown than does standard black and white positive. Since it contains no silver it is much less liable than black and white to catch fire in the projector when any accident happens. We are therefore confronted primarily only with the questions of the desirability of color in general and of the perfection with which Technicolor film reproduces natural color values.

When we compare modern motion picture photography in black and white with the technique of early pictures, we see that a great deal of progress has been made in the perfection of the purely *pictorial* side of the work. We have better definition and more freedom from lens distortions than in the early days. Much greater care is taken in the composition of the pictures from an artistic standpoint. The reproduction of tone values, as Mr. Jones calls it, is more faithful; although in the majority of cases there is a radical departure from naturalness in the case of colored objects, which could be remedied by the general use of panchromatic film. Thus the motion picture industry has shown a pronounced interest in improving its product not merely as a story-teller but as a work of art. I might even say that it has made more progress in the latter direction than in the story-telling direction. This is the more surprising because in my experience the motion picture producers are not large employers of technical or scientific talent, having left most of the scientific problems to the manufacturers of photographic and optical materials. It is somewhat paradoxical that the most intensive scientific studies of photographic problems are not being made by the

producers, and I sometimes wonder whether the latter have read or are capable of understanding what the research experts of the manufacturers have to say.

Now it would seem in view of this evident interest of the producers in a more perfect pictorial result, that they should embrace natural colors as the most important single step forward in their photographic art which has yet been made possible. They have evidenced great interest in the improvement of the motion picture as a pleasing representation as well as a story-telling medium. I can only feel that their slowness in adopting the new medium is due to the bigness of the step, combined with a certain amount of fear which goes with any important innovation. These fears are practical and economic rather than theoretical in their foundations.

I believe that there can be no argument as to the truth that the popular appeal of the motion picture depends fundamentally upon story-telling. Nevertheless, there is some place in a motion picture program for presentations which are purely matters of beauty and which do not tell any significant story. It is quite clear that presentations of this sort are effective on the stage; for example, in musical productions or revues. Here we find numerous acts, the significance of which is entirely lost on the average witness, but which are given entertainment value by movement and color. Color is a very important factor in such presentations and consequently they are ineffective and impossible on the black and white screen. It follows that the introduction of natural colors makes possible the use of ideas and types of presentation which have hitherto been unavailable to the screen. Imagine, for example, putting the Ziegfeld Follies on the screen in black and white. It would certainly be a complete failure no matter how good the stage production might be. But in full color the result would be quite a different one. Motion picture exhibitors still find it possible to "get away" with a certain amount of *scenic* material in their shows, and the proportion of this which would be acceptable to the average audience would undoubtedly be increased by a very large percentage if the scenics were done in color.

The beauties of nature are largely lost in a simple black and white representation. A similar proposition applies to the use of color in *news reels*, which has recently been inaugurated by Fox. The speed of manufacture which is possible by the Technicolor I. B. process greatly facilitates the application of color to this field. Still

another type of picture to which color obviously makes a tremendous contribution is that of delineating the latest *fashions*. In this field a black and white representation sacrifices about three-quarters of the effect. The same situation holds for the majority of advertising, educational, and scientific films, wherein color should have a value proportionate to that which it possesses on the billboard, in the advertising pages of a magazine, or in an educational text.

There is another aspect of the use of color to produce purely aesthetic effects. I note that Mr. Clark says that there are very few persons in the average motion picture audience who are interested in color "as such." I do not know exactly what he intends to imply by this latter phrase. The most radical interpretation would be a reference to something like the so-called color music or color harmony schemes which have interested certain persons. It is undoubtedly true that mere colors in a meaningless pattern have an aesthetic effect, although the grip of color permutations on our pleasure-producing nerve mechanisms is much less than that of the permutations of musical tone. Such meaningless color patterns and changes will certainly not suffice to entertain an audience over any very protracted period. The principal value of color must lie in its use as an accessory to perception and association rather than as a pleasurable sensory material by itself. Nevertheless, there is no reason for denying that it has an appeal of the latter sort. I note that a good many exhibitors are indulging nowadays in the use of color slides which throw a light color haze or color pattern on the screen as an introduction to a picture, or are sometimes superimposed upon the picture to obtain a novel effect.

When we reflect upon the proposition which we have heard from some exhibitors and producers that natural colors make no important contribution to their business, we are led to ask some questions such as the following: Why, then, are all billposters advertising motion picture productions uniformly printed in full color? Why do the distributors go to the expense of getting out lobby posters in color? Why does the national advertising of certain producers in the trade magazines utilize so much color? If it is true that color interferes with the appreciation of comedy, why do all Sunday papers insist on the use of elaborate colors in their comic strips? I might even ask why the press agents insist on describing certain black and white motion pictures as "colorful." I may also point out the continued use of stenciling, although it introduces colors of an

unnatural hue and distribution. Moreover, it is well known that a large percentage of positive film is tinted or toned to introduce more or less uniform colors. The layman sometimes confuses such "colored film" with a description of natural color pictures, although there is little likelihood of his failing to discriminate between them on the screen.

One of the most practical questions regarding color-results is as to how faithful the chromatic reproduction must be in order to be superior to black and white. My own impression is that any color whatsoever is preferable to black and white provided it is in the *direction* of the natural hue. By this I mean that we might introduce a slight amount of color of the same hue (red, orange, yellow, etc.) as the natural objects but of a reduced saturation and that this would be preferable to an untinted black and white. Technicolor has experimented with this idea, which we call "color modulation," and it is possible for us to supply film having any desired degree of color saturation from plain black and white to saturations exceeding normal. It is our impression that normal saturation gives the best average result, but that *super-saturated* colors are not to be desired except possibly in producing weird effects for special purposes. However, observers who have become emotionally attached to black and white pictures find the shock somewhat reduced when they pass to a color picture of reduced saturation. It is also possible to depart to some extent from the natural *hues* of objects without producing an unpleasant effect. In the two-color process, some degree of departure of this sort is necessary, and it is only essential that the departure should not apply to objects whose color is very familiar to the observer. The most important of these is, of course, the group of flesh tints, including the hair. Next to these in importance probably come the greens and browns of vegetation and the blue of skies. It is difficult to get both skies and flesh values satisfactorily at the same time, although if the scene is not too exacting it is surprising how good the result can be made. It is usually not essential that colors of woods, fabrics, and other furnishings should be exactly reproduced, since the observer does not know what the actual colors were.

The psychology of the *two-color process* has many interesting aspects. We know that theoretically three colors are required for complete chromatic reproduction except for partially color-blind observers, most of whom would be completely satisfied with the two-color system. In a two-color process we virtually drop out one of

the colors in the three-color system, and there seems to be no doubt whatsoever that the blue or violet component is the one which is most readily dispensed with. There seem to be a number of reasons which support this choice, the most important of which is that the rendering of flesh tints is not appreciably affected. A close second lies in our familiarity with the appearance of objects under yellow artificial illumination. Ordinarily we do not appreciate that there is any loss of color under such a light. It is only when we are endeavoring to make accurate color matches that we get into trouble in distinguishing fine shades of blue and green or the like. The two-color system is supported to an astonishing degree by the capacity of the brain to reconstruct color perceptions on the basis of memory, provided it has a sufficient clue. The naturalness of a two-color result is often indistinguishable from perfection even to a trained eye. This is not saying that eventually we shall not pass to three colors, but for the present the greater simplicity and lower cost of a two-color system justifies its use as a first step towards the ultimate goal of complete color rendering.

A question which has been considerably discussed has to do with the amount of *fatigue* produced by motion pictures and particularly by natural color as opposed to the black and white picture. Very careful studies by Irvine and Weymann with about one hundred observers showed that ocular fatigue is less after viewing a Technicolor film than after a black and white showing of the same length. The conclusion is also reached that there is less fatigue due to viewing motion pictures than to reading and that those who suffer eye strain in the movie theater usually have defective vision. I do not know how conclusive these studies are, but *a priori* I should expect ocular fatigue to be less the more natural the representation, since any degree of unnaturalness requires compensation on the part of the nervous system. It is therefore not to be expected that natural colors will be any more responsible for ocular discomfort on the motion picture screen than in every-day life; in fact, we should anticipate a *reduction of the discomforts* with the introduction of the natural color film. This anticipation has been born out by the practical comments of many everyday people. On the other hand we must acknowledge that the unnatural color fringing and the super-saturated colors of the first cruder attempts in the color motion picture field led to distressing results.

Now, although I believe that I have shown in the above discus-

sion that the fundamental arguments are all in favor of the natural color motion pictures, nevertheless it would be foolish not to recognize that there are some temporary disturbances in passing from black and white to color, particularly *vice versa*. However, the really important question is not what temporary difficulties may be encountered in the transition from black and white to color but what we may expect when such transitional stages have been passed. Every improvement naturally meets with inertia because of habituation to a more primitive state of affairs.

DISCUSSION

DR. HICKMAN: The claim underlying Dr. Troland's excellent arguments is that full, natural colors are preferable to monochrome, and his query is why have they not been adopted in spite of their slight extra cost. I suggest that the reason lies in what one accepts as "full, natural color." Two-color processes, beautiful as they are, do not give full, natural color; it is a question how far the departure affects average persons—whether they would rather see the picture in black and white or pay extra and see the color.

It is well recognized that though a trained eye is required to appreciate true tone rendering, the most inexpert can detect false color. In this respect all color processes are at a disadvantage. However, by representing true colors in terms of some conventionally accepted scale, very beautiful and acceptable results can be obtained. Some few years ago the underground railway in London published a series of scenic advertisements in complementary colors, with green skies, red trees, and purple fields. The color combinations were chosen by artists and the results were pleasing. Now with your two-color process you cannot leave your choice to an artist; you must choose your two primaries so that in appropriate mixture they pass through the flesh tint range. This leaves your other colors dominated by two hues—brick red and blue green. Any psychologist will tell you that these are not favorite colors, favored neither for modern dress nor to be found in nature.

I do not wish Dr. Troland to interpret these remarks as inimical to his process; I greatly admire its beauty. I merely suggest that the limitations imposed by a two-color combination will make such films delightful to see occasionally but tiresome for a steady diet, and that, that is the reason why they have not been patronized to a larger extent.

DR. TROLAND: It is certainly a question of great interest what the relative utilities of the two-color, three-color and black and white results actually are. The only way to get an answer is by collecting the introspective statements of different individuals regarding their preferences. On this basis we find that by far the greater number of people prefer the two-color result to black and white, although there are some exceptions. My own impression has been constantly that the two-color process at its best gives results which are astonishingly close to perfection, if one bases his judgment on memory rather than on simultaneous comparison.

Of course, two-color reproduction can not be theoretically perfect, but examples of it have frequently impressed even professional artists as being so, a reaction which has been somewhat surprising to us. A great deal depends in the two-color process upon the exact selection of primary colors, and if the best choice is made, it is usually difficult for an inexperienced eye to detect any departure from naturalness of colors. In some two-color pictures which have appeared in the past, the selection of primary colors was ill-advised, causing even the flesh tints, which are the most important colors, to be rendered very poorly. If the flesh tints are properly reproduced, other colors can take care of themselves. I am not advocating the two-color process as the ultimate standard of perfection and look forward to the use of three colors when they become economically feasible, as I believe they may.

DR. MEES: This question as to how far a two-color process is satisfactory is one on which one can argue all night. Personally, I am on the side of Dr. Troland.

There is one field of motion picture photography for which I think the two-color methods unsuitable, and that is landscapes.

One thing Dr. Troland said, which is a source of criticism of pictures in colors, is that subjects which have been a failure in black and white have been a success in color. That is one trouble; too many color pictures have been made with the belief that the color would save a picture which didn't have any story.

DR. TROLAND: I am very glad to have the support of Dr. Mees, because I have a high esteem for his judgment in such matters. I am inclined to agree with him concerning the desirability of not doing any more scenic work by the two-color process than is necessary. However, we are under the orders of the producers and directors and have to photograph the subjects which they set before us. This

applies also to the tendency to use color to strengthen a weak story; a principle which is also concerned in the use of "stars." If a story is strong enough to get across without a star, the producers usually dispense with the latter, so that the stars commonly find themselves associated with a poor story.

However, I believe that it is significant as to the box office value of colors that such a production as "The Black Pirate," which was not strong as to dramatic action, can show good financial returns. Nevertheless, if the producers were wholly wise in their use of color, they would combine it with features which are good in other respects, thus raising the general quality of the production to a level which could not otherwise be attained at all. This has been done in such pictures as "Ben Hur" and "The King of Kings."

MR. RICHARDSON: I have long been convinced that projection methods as applied to color are in urgent need of attention. Hundreds of projectionists have realized that something was not right and have written me in an endeavor to locate the cause of the trouble. I am convinced that the sponsors of color will not be entirely successful until they not only further their process of making but also find some means of insuring that the color values will not be distorted on projection. The blue, for example, must not appear as a dirty bluish gray.

Some time ago I witnessed the projection of a color subject in a small theater. The colors appeared very beautiful on the screen. I went up to congratulate the projectionist, whom I found to be using a 900-watt Mazda light source and projecting a rather small picture. The week following I was in a large theater while the same production was projected, and it most emphatically was not beautiful. The light source was a high power intensity arc, which tended to "wash out" the colors until what remained was not pleasing. I spoke to the projectionist, asking why he did not reduce the light power as much as he could. He was astonished at the suggestion. His view was that color was relatively dense, hence needed all the light it was possible to use.

I believe color advocates must adopt some method of educating theater managers and projectionists to the fact that the projection light source must be carefully matched in both its power and tone to the requirements of color work. I shall personally be very willing to give them any possible aid to that end. I am of the opinion that the harsh, bluish light of the high intensity arc is not well adapted to the projection of color films.

DR. TROLAND: I quite sympathize with Mr. Richardson's remarks on the outrageous projection conditions which exist in many theaters, since we have made extensive studies of this matter ourselves. It is true that the projection of natural color pictures requires more expert handling than in the case of black and white. It is desirable to have at least 10 foot-candles of illumination on the screen, and the color of the light source is of the utmost importance. It is unfortunate, from our standpoint, that the majority of theaters use the high intensity arc, because two-color pictures are best seen under Mazda lamp illumination, which is practically non-existent even in the smaller theaters. Our present single-coated film has a rather strong tint which is designed to color-match the high intensity arc to a high efficiency mazda lamp. Some degree of compromise is necessary, however, but it is fortunate that the effect of the tint on Mazda lamp projection is relatively unimportant, while with the high intensity arc there is a marked improvement regarding the "washing out" of the colors. I believe that it is impracticable to try to coerce the exhibitors or projectionists into adopting any particular kind of equipment for the showing of color film.

MR. KELLOGG: I guess we all recognize what a tremendous factor education is and how we can become accustomed to anything which is not quite a perfect reproduction of nature. In accepting black and white photography we have a long process of education behind us not only in attending the movies, but from babies we have become accustomed to looking at black and white pictures. On a moonlight night, for example, we admire everything about us, but there is almost a total absence of color. All that means that we can accept the colorless motion picture with the usual amount of satisfaction.

When viewing the talking movies I have been struck at once by the fact that when a person begins to talk, his ghostly appearance becomes more impressive. Education may overcome this little barrier, so that I cannot say whether the advent of talking pictures will increase the demand for color or not; it will stimulate it, if anything.

DR. TROLAND: It is certainly true that night vision is colorless, or at any rate is a bluish monochrome if not strictly neutral. We have had amusing experiences with producers who want to do night scenes in color, whereas in my opinion these are the only kind of scenes which should be done in black and white or monochrome.

The relation of color to talking pictures is interesting. We have frequently heard the comment which has been offered by Mr. Kellogg concerning the unnaturalness of the black and white image when it begins to speak; and I believe the combination of color with sound will strengthen the total effect by producing a more harmonious relationship between the screen and the sound reproducer. We have already made numerous tests on the combination of color with a number of talking movie systems.

MR. GREENE: In regard to illumination, Dr. Troland recommended an illumination of at least 10 foot-candles; does that include shutter loss and does it assume a plain white screen? If I heard correctly, I understand that there is less danger of fire with Technicolor than with other film. Could Dr. Troland elaborate on that point?

DR. TROLAND: There is no absolutely prerequisite intensity, but we favor one of about 10 millilamberts, which is about equivalent to a 10 foot-candle illumination on the average screen. The measurement is made with the shutter running and is the apparent brightness of the screen under these conditions. Regarding the relative non-inflammability of Technicolor positive, this is due to the fact that the film contains no metallic silver to absorb the heat rays and raise its temperature to the ignition point. The coloring materials which are used are almost wholly transparent to infra-red radiation, and they have about the same absorption as gelatin or film base. Of course, the nitrocellulose base is just as inflammable as ever, but the heat passes through instead of being taken up by the film. We have found it possible with a Mazda lamp source to stop the film in the gate indefinitely without its being ignited. However, this is not recommended with a high intensity or other arc lamp.

MR. IZAACS: What screen is recommended for the best reproduction?

DR. TROLAND: I am not the expert in this matter, but I think a matte white screen as nearly as possible neutral. I should not recommend aluminum or a semi-direct reflecting type of screen.

MR. STEWART: A little while ago I was with Dr. DeForest, and I told him I thought it would be splendid to combine color and talking pictures, and he said: "Not on your life, Stewart. I don't want anything to detract away from our talking film. Give me a third dimension, and I won't ask for anything else."

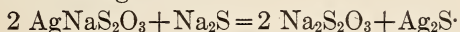
AUTOMATIC SILVER RECOVERY FROM HYPO

K. HICKMAN AND D. HYNDMAN*

THERE are so many ways of recovering silver¹ from spent hypo that it is difficult to recommend a best scheme. This must vary with the circumstances and with the bulk of the solutions handled. The chemical reactions which are most favored employ sodium sulphide or zinc dust,² precipitating the silver as sulphide or as metal. Both sodium sulphide and liver of sulphur are soluble in water and may be added by measure in solution to the hypo, whereas the solid zinc dust has to be weighed or scooped out. The latter is, therefore, not so suitable for a continuous process.

Silver recovery as usually practiced is an intermittent matter. In the basement of every film laboratory there are to be found a couple of large tanks for receiving waste fixing bath. While one is slowly filling, the contents of the other are being treated and the silver allowed to settle out. Where moderate quantities of liquid are concerned, this is an excellent procedure. When, however, the bulk exceeds five hundred gallons a day, the manipulation and the collection of precipitate becomes tedious and the room occupied by tanks and filters quite considerable.

The apparatus now to be described was developed to accomplish the recovery operation continuously in a small space and with little trouble. The novelty lies in the apparatus and not in the chemistry, which follows usual practice. Sodium sulphide is the precipitant according to the following reaction:



The problem is to add the right quantity of sulphide solution to a varying stream of hypo and to separate out the precipitated silver sulphide continuously. In deciding the design, the assumption was made that the silver content of the spent fixing bath would be approximately constant so that a given bulk of it could always be treated with a predetermined bulk of sulphide solution. One essential point in the design was therefore a hypo measuring unit. The other essential was a supply of alkali so that the hypo

* Eastman Kodak Company, Rochester N. Y

should always be rendered distinctly alkaline before the addition of sulphide. The slightest trace of acid would liberate hydrogen sulphide, which would be unpleasant as well as dangerous to metal work and to undeveloped film. A convenient supply of alkali was found in spent developer.

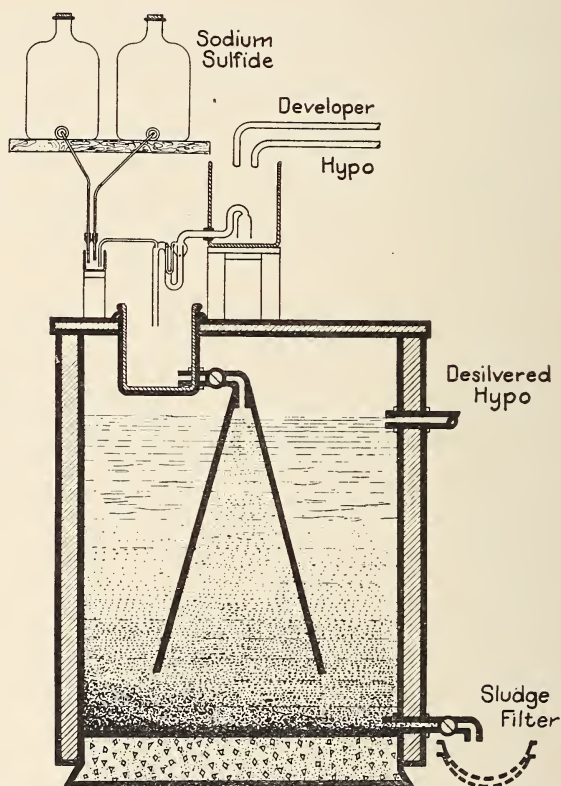


FIG. 1. General Diagram of Silver Recovery Apparatus.

The device for measuring the hypo follows the principle suggested in a previous paper.³ A doubled-knee syphon blown in two parts from Pyrex glass is mounted by means of a rubber bung through a hole in an earthenware crock and allowed to hang over a second crock also provided with a drainage hole. Both crocks are mounted on the top of a cylindrical wooden tank of some three hundred gallons capacity. Inside the tank is hung a funnel shaped tube conveniently made from sheet celluloid, down which solutions may run from the

second crock. The tank has two openings, one at the bottom to discharge a sludge and one near the top for the overflow of desilvered hypo. On a small platform near the top crock rests a shallow trough of sodium sulphide solution. A tube leading from the outflow limb of the syphon dips into the sulphide and conveys a measured portion into the hypo each time the syphon flushes. The sulphide trough is fed by a chicken-feed arrangement from two large bottles on a shelf

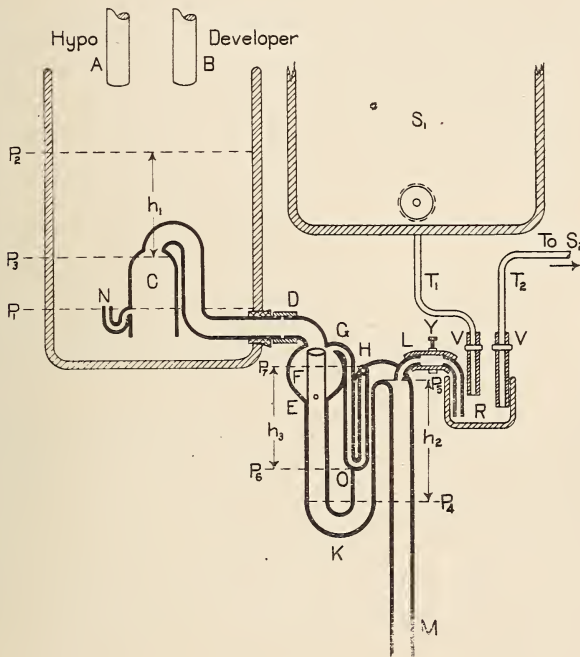
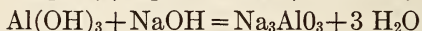
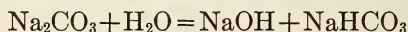


FIG. 2. Detail of Syphon.

above. Filters at the base of the tank complete the outfit. The general assembly is pictured in Fig. 1, while the syphon, with dimensions adequate for a maximum of one hundred gallons per hour, is shown in Fig. 2. A detailed description of the action will now be given.

Referring to Fig. 2, pipes A and B convey hypo and all the available spent developer to the top crock. The acid hypo generally contains hardener and will on neutralization produce a precipitate of aluminum hydroxide or chromium hydroxide according to whether

potash alum or chrome alum has been used in compounding the bath. In the former case the excess alkali dissolves the alumina thus:



This gives a sludge fairly free from alumina and one easily filtered. In the case of the chrome alum the extra alkali has little solvent effect. It does, however, diminish the hydrolysis of the sodium sulphide and therefore suppresses objectionable smell.

The mixture of hypo and developer is allowed to run into the top crock whilst a cork is placed in the open end of the long syphon limb M. When the crock is nearly full, the cork is withdrawn and the syphon allowed to discharge. Liquid rushes out until the crock is empty, when air is sucked in at the break tube N in the inverted bell C. This breaks the liquid column and allows the crock to fill up again. The rush of liquid during emptying, however, is so great that when the syphon is broken, the inertia of the water leaves the main tube almost empty. Since, however, a liquid seal must be maintained in the bend DKH, a bulb E is provided which saves liquid for a few seconds and acts as a storage system to replenish the bend through the small hole F. It also provides liquid for the control tube GOH.

Consider what happens when the crock fills. Liquid rises equally outside and inside the bell C until the level P_1 is reached. Liquid now seals the break tube N and the level increases outside C but cannot do so to the same extent inside, since there is nowhere for the contained air to go except into the syphon which is, however, sealed at K and O. A constantly changing equilibrium becomes established until the level P_2 is reached in the crock. The level in C will then be at about P_3 with the levels in DKL and GOH at P_4 , P_5 , P_6 and P_7 . To maintain hydrostatic equilibrium the level differences must be such that $h_1 = h_2 = h_3$. If now the crock continues to be filled, h_1 and h_2 will increase, but h_3 will be unable to do so because the level at P_6 has reached the bottom bend in GOH. The increase in pressure will therefore force the liquid around the bend and discharge it suddenly in to HM. The air pent up within the tubes now rushes out and is replaced by liquid which initiates syphon action and empties the crock once more. The cycle then repeats.

It is during flushing that the side tube L comes into play. For reasons described elsewhere, when the limb HM is full of liquid, even though the liquid is running freely under its own acceleration,

a negative pressure slightly less than the head of a stationary column of liquid of height LM , is developed at L . Since L communicates with a trough of liquid R (sodium sulphide solution), sulphide will be sucked in during the flushing period. Now this period is one of constant duration; the time taken to empty a crock from one predetermined level to another through a tube of constant dimensions. Therefore each time the crock flushes, the same amount of spent hypo will be delivered and the same quantity of sulphide administered through the side tube. All that is needed is that the level in the sulphide trough shall be approximately constant. This has been accomplished by mounting two 20-liter glass bottles S_1 and S_2 a little above R and allowing stout rubber tubes T_1 and T_2 to hang from tubulures to below the surface in R . Pinch cocks close the tubes at will. To fill the bottles, the rubber tubes are pinched, the corks withdrawn, the sulphide solution poured in, corks inserted tightly, and the tubes unclipped. Whenever the level in R falls below the ends of the tubes, air leaks in and allows a little sulphide to flow down. Two bottles are used so that when one is empty the other can function during filling. It is convenient to have one tube T_1 a little longer than T_2 .

The action of the measuring unit is to give a series of intermittent rushes of treated hypo solution. Fluctuations in discharge from the film processing machinery are taken care of by variations in the time the top crock takes to fill. The function of the second crock is to store the mixed hypo and let it gently into the settling tank so that the sludge shall not be unduly disturbed. This crock is therefore fitted with a constricted orifice so that each unit of solution can leak away in the interval between two flushes at peak load.

Fig. 1 depicts the whole assembly. The crocks are mounted on the top of the settling tank and when once adjusted need no attention whatsoever. The film base funnel is made of material sold for side curtains of automobiles. It is 4 feet long, 18 inches wide at the base, and 2 inches wide at the top and is joined at the seam by ordinary film splicing cement. It is suspended by a saddle from the second crock orifice. Its action in settling the precipitate is best seen from the shading in the diagram.

Collecting the sludge of alumina and silver sulphide is quite straightforward. The desilvered hypo, brown from developer but quite transparent and free from precipitate, flows to waste from the top of the tank. The sludge is best drawn off daily from the

bottom, being allowed to run into a large porcelain filter crock. These crocks are about 20 inches in diameter and are used two at a time with a layer of filter cotton between, as in Fig. 3. When filtering becomes slow, the contents are scooped out and transferred to one of a series of old buckets having a few holes knocked in the



Diagram of Filter for Silver Sludge

FIG. 3. Filter Crocks.

bottom, the holes being covered by a piece of felt. Here the sludge slowly drains out leaving a solid black cake in a week or so. At the end of the month, the cakes are tipped out and sent to the refiner. The buckets are then ready for use again without further preparation.

Care and Maintenance

When once the measuring unit has been adjusted, the outfit requires no attention save keeping the bottles filled with sulphide and the filter crocks lined with fresh cotton. Initially, however, the unit requires adjustment. For this purpose the screw pinch clip *Y* on *L* is opened to its fullest extent and the syphon allowed to flush. A large excess of sulphide is thus drawn in. At the moment flushing ceases, a glass beaker is dipped into the second crock and a few ounces of fluid withdrawn. This is filtered through a water pump or allowed to settle and is then tested by the addition of a further drop of sulphide. There should be no precipitate. The screw clip *Y* is now tightened a little and another sample of liquid taken after the next flush and again tested. This is repeated until finally a stage is reached when a black cloud after the addition of sulphide to the filtered samples shows that insufficient reagent has been sucked past the clip. The trough *R* is then withdrawn and a measuring cylinder full of water substituted. The quantity sucked from the cylinder is noted after a flush, and the clip is unscrewed until double

the quantity is withdrawn at each emptying. This quantity is noted and preferably marked in ounces or cubic centimeters in bold letters on the top crock for future reference. To check the adjustment of the amount at any time subsequently it is only necessary to substitute a measuring vessel for *R* and turn the clip until the correct quantity (allowing thus about 50% excess) is delivered. The apparatus is now ready for service.

The sodium sulphide or liver of sulphur solution is conveniently made in about 20% concentration. Any good quality fused commercial sodium sulphide costing only a few cents a pound may be used. It is placed in a bucket and a gallon of water added for every 2 pounds of sulphide. It should yield a black solution, red in thin layers. After an hour's settling it should decant as a clear brown fluid. It is then ready for placing in the bottles.

Performance

The somewhat complicated apparatus might be thought a mere laboratory dream finding no counterpart in practice. As a matter of fact, two units exactly as described are in use and function absolutely reliably. They have reduced the labor of reclaiming hypo to a fraction of that required previously. Where waste developer is not available, the sodium sulphide solution is made up with three times its weight of caustic soda, so that both sulphiding and neutralization can take place through the side tube of the main syphon. The only added adjustment found necessary where developer is used in place of pure caustic is an occasional cleaning of the glass syphon with nitric acid to remove a deposit of silver accruing from the action of the reducing agent on the charged hypo. It is not feasible to use the desilvered hypo over again for fixing purposes.

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DISCUSSION

MR. COWLING: Can the syphons be purchased on the market?

DR. HICKMAN: I have been devoting much attention to self-priming syphons for the last five or six years because they can be put into operation without any mechanical effect. The essential idea of compressing air in a double knee syphon has been covered by a German patent which I have mentioned in a previous paper. To overcome the difficulty of the priming solution over-running the system, the German inventor employs complicated balance pipes. We incorporate a little bulb to store the priming liquid and accomplish the end much more simply, permitting the water to rush into the knee without filling up the bulb and thus preventing the air escaping here at the start. I believe we are the only people who can blow the syphons at the present time. If we had a very urgent order, we should be pleased to make one for anybody.

MR. ROSS: How is the Sludge removed?

DR. HICKMAN: In a tank such as we use here, there would be 500 gallons of liquid accumulating about \$100 worth of sludge on the floor before it begins to flow out. This is a capital investment in the tank to save you the trouble of making a sloping floor. You can drain out continuously all but this quantity if you have a flat floor. With a sloping floor it comes out very nicely. The thickness of the sludge can be controlled to a nicety all the way from a dark liquid to a thick black cream by adjusting the rate at which it is withdrawn. There is never any difficulty in getting it out of quite a small bung hole. The thickness of effluent which is chosen depends entirely on the means employed to filter it. We choose a sludge thickness like that of slightly whipped cream.

DR. SHEPPARD: What is the tolerance of temperature in such a device; that is, the dimensions of the air bubble will vary with the temperature, and there must be a tolerance for temperature change in such a case?

DR. HICKMAN: It doesn't matter much what the size of the air space is provided it is above a certain minimum. Temperature, therefore, has no effect outside the danger limit of size.

BEHAVIOR OF GELATIN IN THE PROCESSING OF MOTION PICTURE FILM*

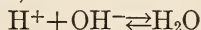
S. E. SHEPPARD

THE mechanics of motion picture film are largely determined by its make-up as a layer of strongly water-absorbent colloid secured to one of slightly water-absorbent colloid. Naturally the boundary between these relatively wet and dry states is subject to considerable stress, and it sometimes happens that the union between them does not prove indissoluble. I propose to describe in the following, in a rather general way, some of the peculiarities of gelatin in the matter of swelling and shrinking, especially as affected by the solutions and conditions used in photographic processing.

The effects possible range from alteration of the strength and flexibility of the film to minute alterations of the photographic image itself.

Influence of Hydrogen Ions

The behavior of gelatin in not too concentrated aqueous solutions of salts and other bodies is covered in a large degree by the acidity or alkalinity of the solution. It is convenient to express the range of transitions from high acidity to high alkalinity of chemical solutions on a single scale, just as we express degree of heat by temperature. Degree of acidity is supposed to be due to the concentration of hydrogen ions. Assuming that neutral water results from the equilibrium of the reaction,



we see that the neutral point will be defined by the presence of equal concentrations of hydrogen and hydroxyl ions. This corresponds actually to a concentration of $C_H = C_{OH} = 10^{-7}$ gram molecules per liter. The acidity is directly expressed as the concentration of hydrogen ions, but this will give us a scale of inconvenient figures, such as 10^{-12} , 10^{-7} , 10^{-2} , etc. It is much more convenient to take logarithms of these, when $-\log C_H = p_H$. This scale will express both acidity or alkalinity, and points on the scale may be deter-

* Communication No. 326 from the Kodak Research Laboratories.

mined either by the use of a hydrogen electrode by electromotive force measurements, or more conveniently in most cases by the use of indicators; that is, of dyes which change color at certain definite p_H values.

I must pass by here any reference to methods of exact control of the p_H of solutions, merely noting that the p_H value is only definite in solutions which are said to be "buffered." By "buffering" a solution is meant the adjustment of the chemical equilibrium in the solution such that the concentration of a certain component will be maintained nearly constant even when the solution is considerably diluted or the equilibrium disturbed in other ways. As an example, if we have a solution containing acetic acid together with sodium acetate, the hydrogen ion concentration will remain relatively constant either on dilution or on the addition of considerable amounts of alkali or acid. The sodium acetate being the salt of a weak acid with a strong base dissociates giving certain amounts of acetic acid and a certain amount of caustic alkali. Therefore, in the presence of excess of sodium acetate, the addition of alkali merely removes a certain amount of free nondissociated acetic acid, leaving the sodium acetate equilibrium nearly at the same point. It is important to note that statements concerning the relation of a given effect to the p_H value do not have full significance unless they refer to "buffered" systems. It so happens that gelatin is a substance having a considerable "buffering" action, so that we may treat gelatin with not too strong acid or alkaline solutions which are thus "buffered," and obtain a system which is in equilibrium.

The swelling of gelatin in aqueous solutions is very markedly affected by the hydrogen ion concentration. Fig. 1 gives a picture of the behavior of gelatin in solutions at different p_H values. It will be seen that a definite minimum of swelling occurs at a point not far from a p_H of 5. It can be shown by methods which I cannot delay to specify now that this point of minimum swelling coincides with what is termed the iso-electric point of gelatin. This means that gelatin behaves in solutions of higher p_H than 5 as though it were negatively charged, and in solutions of p_H lower than 5 as though it were positively charged. Another expression of this relation is that in solutions of p_H greater than 5 gelatin tends to combine with alkalis, and in solutions of p_H lower than 5 it tends to combine with acids. This ambiguous behavior is partly due to the fact that gelatin behaves in many ways like an amino-acid, such as glycine(NH_2CH_2

COOH), and can therefore combine with acids through the amino group and combine with alkalis through the carboxyl group. There has been much debate among chemists as to whether gelatin really forms definite chemical compounds with acids and bases or whether it forms only indefinite so-called absorption compounds. It is not necessary for us to take sides in this matter, but we may at once note that the theory of definite chemical combination has yielded

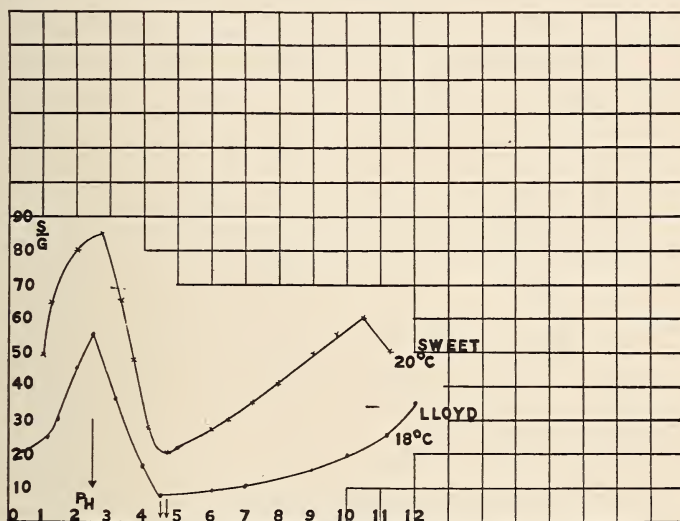


FIG. 1. The Swelling of Gelatin in Acid and Alkali.

useful quantitative expressions for determining the degree of swelling of gelatin in solutions of various acids and bases. The explanation of the swelling of gelatin in acid solution on this view is as follows:

It is assumed that the gelatin combines with the acid, say hydrochloric, forming a salt-like body which we may call gelatin chloride. This body is supposed to ionize into a large poorly diffusing gelatin ion and a readily diffusing chloride ion. The firm gelatin is supposed to have in addition a framework, something like a sponge, of nonionized iso-electric gelatin, and at any given concentration of the hydrochloric acid there will tend to be a definite amount of the neutral gelatin colloid and of the products of dissociation of this, the positive gelatin ion, and the negative chloride ion. It is further assumed that the diffusible chloride ions imprisoned in the gelatin framework effect an osmotic pressure and that the gelatin will con-

tinue to swell; that is, to take up water until the chloride ions within the gelatin are in osmotic equilibrium with those in the outer solution. Increase in the concentration of the chloride ions in the outer solution will eventually repress the ionization and more than offset

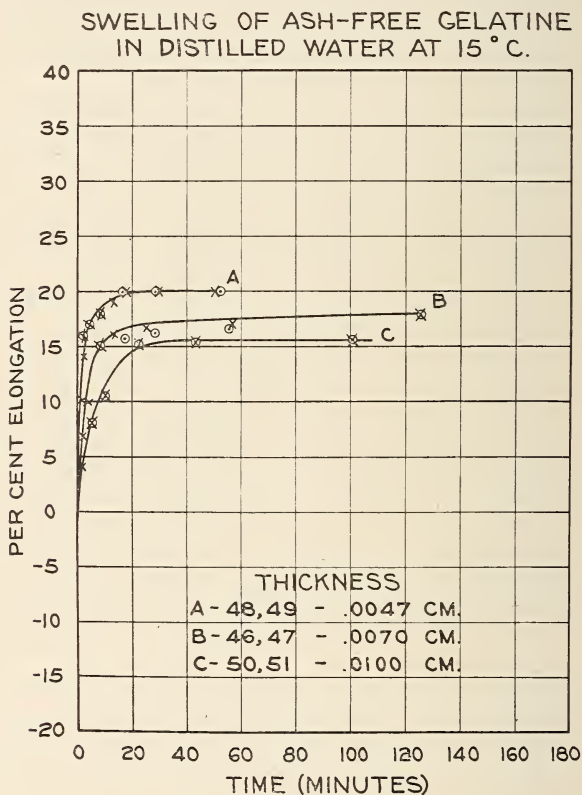


FIG. 2.

the tendency to swell produced by the greater amount of gelatin salt formed, so that the swelling will tend to diminish after a certain maximum concentration of acid has been reached. The theory of swelling based on this conception has been treated mathematically and a correlation reached between the measured results and those predicted by the theory within certain limits. This theory does not, however, give us much help in explaining why gelatin should have any tendency to swell at the iso-electric point, nor does it explain

a number of peculiarities in the swelling of iso-electric gelatin. For example, if we make up jellies of different concentrations, say 5%, 10%, and 20%, keeping these approximately iso-electric, so that the swelling is not complicated by the factors just mentioned, and dry these jellies, on replacing the dried gelatin in cold water it will

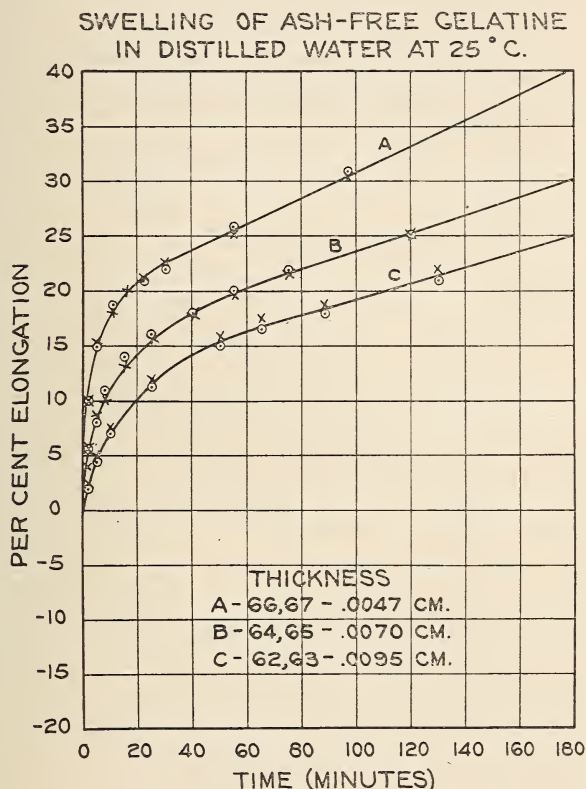


FIG. 3.

be found to swell to a limit depending upon the original concentration of the jelly. For example, the dried gelatin from a 5% jelly will swell to a much greater extent than the dried gelatin from a 20% jelly. It is reasonable to assume that there is a different structure in the gelatin from the 5% jelly than in that from the 20% jelly, and one which allows it to take up a larger amount of water.

We have spoken here of the gelatin swelling to a limit. If we put a piece of gelatin in water at moderate temperatures, for example

at about 15°C ., the gelatin will swell to a limited extent as is shown. If, however, we raise the temperature much above this point, the gelatin will go on swelling without limit and will ultimately take up

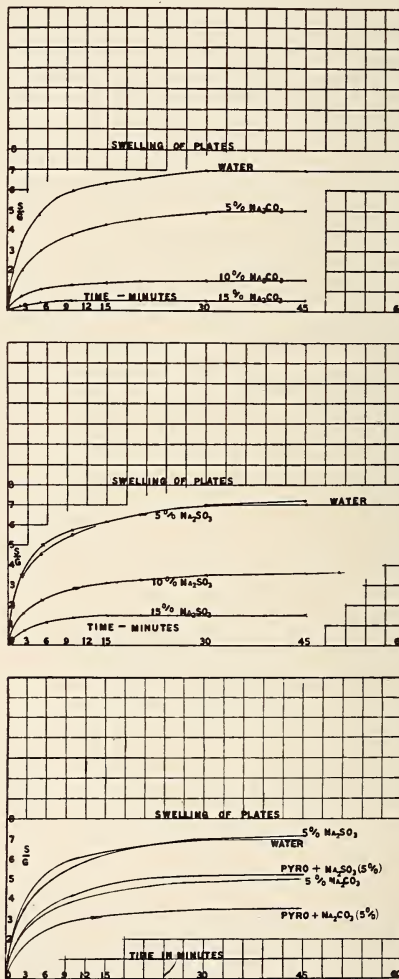


FIG. 4.

all the water offered to it, and the jelly will break up into very small pieces. If at this higher temperature, however, we replace water by a salt solution, we can now get a limited swelling at the higher tem-

perature. It will be seen from this that the swelling of gelatin is a process complicated by many factors. We may note as an additional factor the influence of the actual size or more specifically the thickness of the dried gelatin layer. The accompanying curves show that the actual thickness has a definite influence on the degree of swelling and on the point when limited swelling passes over into unlimited swelling. (Figs. 2, 3, and 5).

In processing a motion picture film, the gelatin will have to go into solutions which are alkaline, into solutions which are acid, and into more or less neutral solutions, and into plain water. The order in which it goes through the solutions, an order which is dictated by the necessities of the photographic process, will greatly affect the swelling of the gelatin and the forces exerted upon it. We have so far spoken of swelling with the sole understanding that this meant increase in volume by taking up water, but we have not specified how it should be measured nor whether it was uniform in all directions or confined to certain directions.

Now it is obvious that a layer of gelatin adhering to a photographic support can only swell in any marked degree in a direction perpendicular to the surface of the support. Otherwise our pictures would have no definite dimensions and would not remain attached to the base. But how is it with a free sheet of gelatin not permanently attached to a more or less rigid support which does not swell to any great extent? Actually, if we dry gelatin down on glass sheets so prepared that we can strip the dried gelatin off, it will be found on placing the sheets in water that the greatest expansion due to swelling still occurs in the direction perpendicular to the surface or the main area of the sheet. There is now to be observed, however, a considerable sidewise or lateral expansion on swelling, showing that when the sheet is attached to a rigid base like glass or film support *a very considerable force is exerted which tends to move the gelatin relative to the support, and the amount of this force will be largely proportional to the total swelling of the gelatin.*

In this connection we may notice another very peculiar and interesting effect. In making experiments on the ratio of the lateral swelling to the total swelling of dried gelatin sheets, measuring the amount of swelling at different times from the period when the dried gelatin is placed in water, it was observed that at the very start an actual contraction of the area of the sheet took place followed by an expansion (See Figs. 6 and 7) yet the gelatin was actually absorbing

water and swelling, that is, increasing its volume from the very start. On further examination of this peculiarity, it was found that the initial contraction vanished when the water was kept below a certain temperature and further that the temperature at which the contraction appeared depended upon the thickness of the gelatin layer.

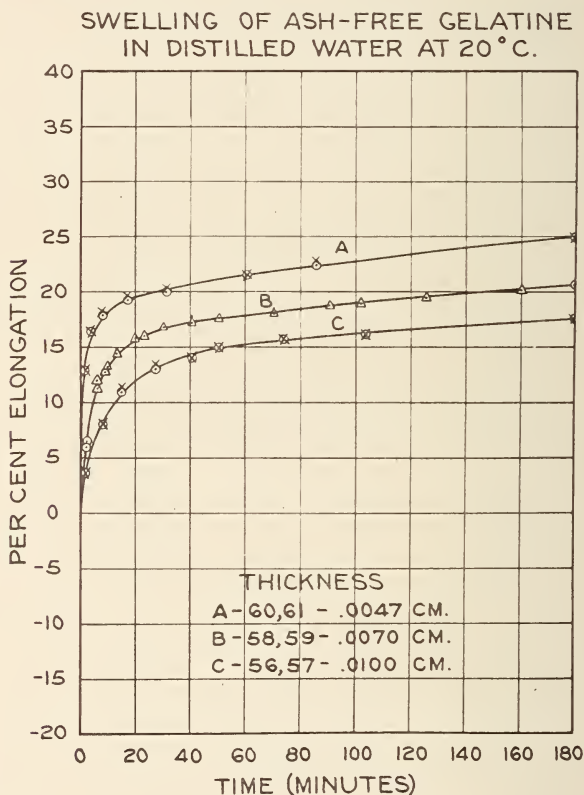


Fig. 5.

Without at this time attempting anything like a complete explanation of this behavior, this is further evidence of the forces at work in swelling which are tending to effect a rearrangement of the particles in the gelatin layer.

Sequence of Swelling Effects in Photographic Processing

When a photographic film is run through a treatment in which it passes from plain water to an alkaline developing bath and then

through a plain water wash, then into an acid fixing bath, and then again into plain water, the gelatin is going through a cycle of swelling and deswelling changes which may test its tenacity to the utmost. If first placed in plain water it will tend to swell, and if the temperature is not high, this swelling will tend to a limit. Usually, however,

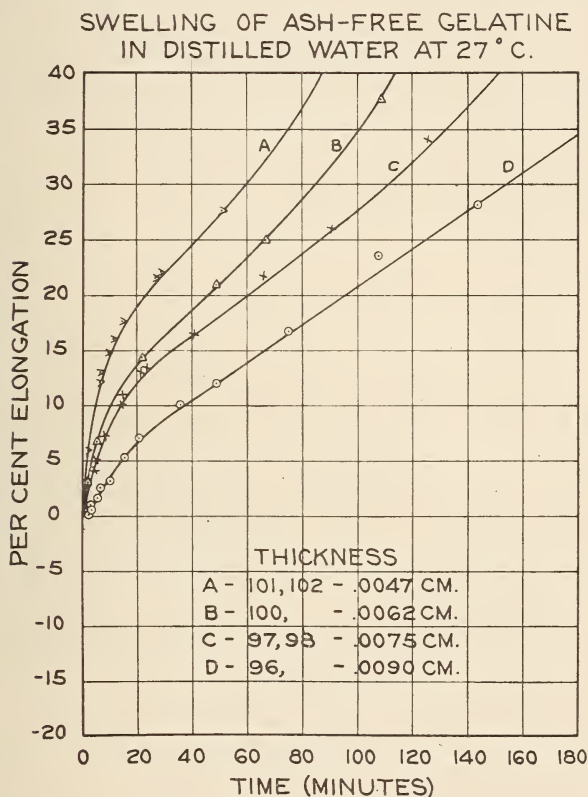


FIG. 6.

it will not be long enough in the water to attain its limit before it is placed in an alkaline developing solution. In this solution it will tend to swell still more, and if the alkaline solution did not contain salts such as sodium sulphite and sodium carbonate in considerable concentration, the swelling would tend to be of the unlimited type effecting disintegration of the gelatin. Immediately on washing in water the swelling will be increased again depending, however, upon the

temperature of the wash water. On removing from the wash water and placing in an acid fixing bath, the swelling greatly diminishes. This will be understandable on referring to the first figure, in which it was shown that a swelling minimum exists between the alkaline and acid conditions, alkaline and acid referring here to the iso-electric point of gelatin. On removal from the acid fixing bath and placing

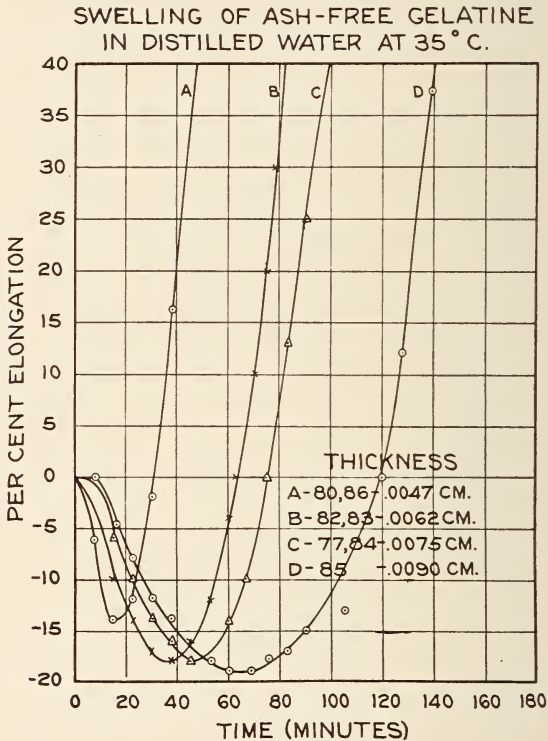


FIG. 7.

in water to wash out the hypo, the gelatin will swell again. The typical course of the swelling under these conditions is shown in the accompanying diagram.

These results were obtained at room temperature of approximately 25°C. The ups and downs would be much more pronounced at higher temperatures of the solutions and with longer times of action.

Perhaps the most critical factor in this series of changes is the passage of the gelatin back through the iso-electric point. I think there is no doubt that an adequate washing and rinsing be-

tween the alkaline developing bath and the acid fixing bath is eminently desirable.* Apart from the carrying over of alkaline developer into the fixing bath and the accompanying dangers of further silver reduction and neutralization of the fixing bath, the actual process of neutralization which will take place first at the surface of the gelatin is not good for this.

Swelling and Elasticity

The absorption of water and the process of swelling must be regarded as impressing a strain on the gelatin. Gelatin and gelatin

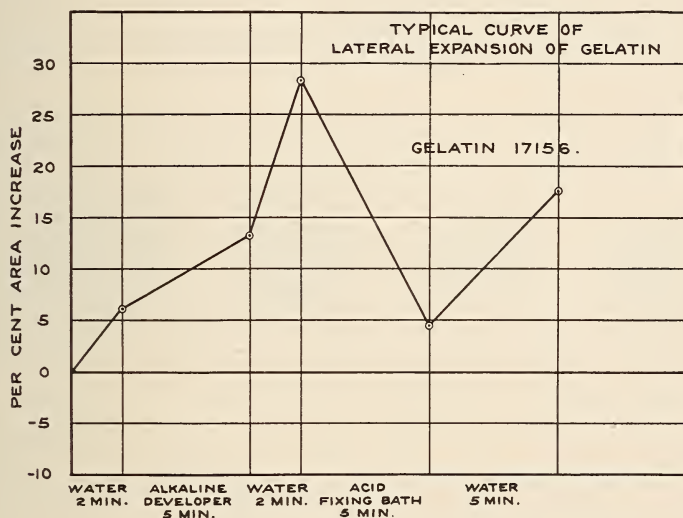


FIG. 8.

jellies have in addition to bulk elasticity the property of rigidity or elasticity of shape. When a material is stressed, it is desirable to keep the stress below the elastic limit if permanent deformations are not to be produced. In the case of gelatin, this means that undue swelling must be avoided. The type of swelling which was termed *unlimited swelling* indicates that the gelatin jelly has been strained beyond the elastic limit and is liable to permanent deformations. We have already noted that causes tending to produce this are high acidity, high alkalinity, and high temperatures in the solutions.

* It will be shown in a later communication that this is a danger point in the process, and requires special adjustment.

Drying of Gelatin

The reverse process of swelling is the removal of water or drying. Just as swelling imposes a strain on the gelatin, so also does drying but not necessarily a strain exactly reversing the swelling strain. Drying involves two principal phases:

- A. The diffusion of water to the surface of the jelly.
- B. Evaporation of water from the surface.

If process (B) is much more rapid than the diffusion process (A), that is, if the latter cannot supply water to the surface as fast as it is

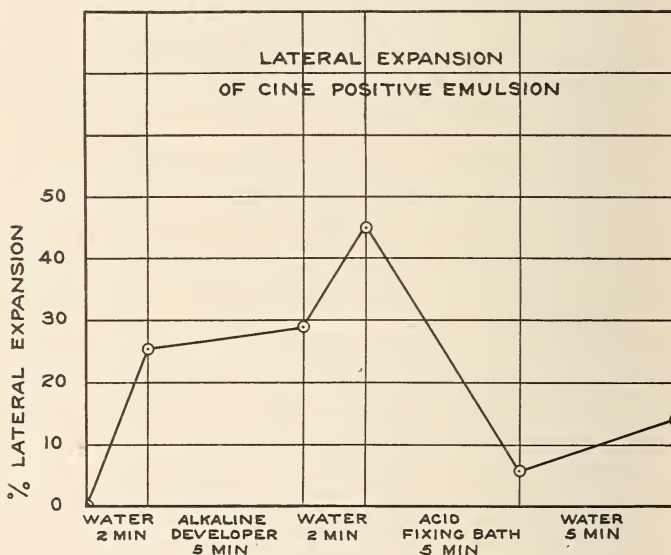


FIG. 9.

removed by evaporation, strains involving persistent deformations will be set up. Indeed, this generally happens in some degree on drying gelatin materials, because to carry out drying under the ideal conditions prescribed above would be too slow in practice.

We can readily observe what is involved in drying gelatin fairly rapidly. If we mold some cubes of gelatin jelly, suspend these freely by wires in a dry atmosphere, which may be kept evenly circulated, we get a picture of the drying process. The water is first removed from the corners and edges. This corresponds to the fact that with photographic plates and films drying starts from the edges. With the cubes, on continued drying a peculiar shape is developed, showing

that very great strains are set up in the drying and distorted mass, and these strains can be observed directly with a polariscope. With gelatin layers drying on supports, such as glass or film support, the strains produced are held in check at the interface between the support and the gelatin or emulsion. There is, however, a factor in drying which assists the situation as compared with swelling. This is the fact that with increased drying the gelatin is becoming more and more solid, that is, more and more rigid and resistant to stress.

The forces operating at the interface on drying may be visualized in another way. On swelling photographic emulsions, the swelling generally is confined to the direction perpendicular to the support. Similarly on drying the contraction is again confined to this direction. Since the drying does not take place exactly reversibly to the swelling,

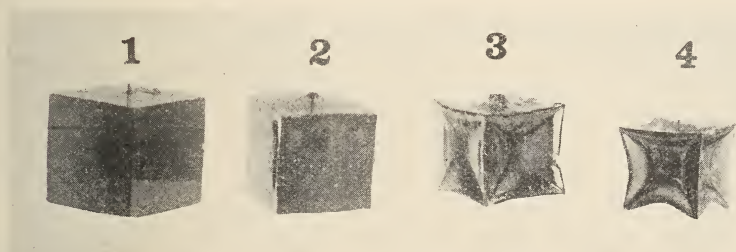


FIG. 10. Shrinkage of Jelly Cubes on Drying.

a new strain is produced on the material. If sheets of gelatin are allowed to swell, it has been noticed already that they have a lateral expansion as well as a perpendicular expansion, the latter being much the greater. We cannot very well measure the contraction of area on drying of free swollen gelatin sheets, because the material curls and cockles. We can, however, measure the contracting tendency in the following way: If the gelatin is coated on supports of known rigidity and thickness and then allowed to dry, the degree to which the rigid support is bowed measures the contractility of the gelatin. It is understood that drying is carried to equilibrium with an atmosphere of definite humidity or vapor pressure. A number of measurements made in this manner are given in the following table.

It will be seen that not only do different types of gelatin vary in this property, but also that different treatment of the gelatin with different reagents changes its behavior in this respect. This lateral contraction of the gelatin is the chief cause of the tendency of the

TABLE I

Gelatin	Volume Swelling	Area Expansion	Area Expansion for 1000%		p _H	Contractility
			Volume Swelling	Area Expansion		
Commercial "hard" A	980	20.6	21.05	5.3	0.041	
" " B	1031	25.7	24.50	5.2	0.040	
Ossein gelatin	2585	86.0	33.40	5.0	0.038	
Hide gelatin No. 6902	815	12.7	15.60	5.3	0.032	
De-ashed No. 6902	784	15.0	19.10	4.8	0.032	
Sizing	1332	63.7	47.80	5.6	0.029	
Hide gelatin 9840	1030	43.0	42.01	5.5	—	

TABLE II.

% CH ₂ O	Volume Swelling %	Area Expansion %	Relative Area Expansion for Volume Increase of	
			500 %	1000 %
0.0	460	11.5	12.5	
0.25	240	10.6	24.2	
0.50	245	10.4	20.4	
1.00	200	9.7	24.2	
2.00	150	7.4	24.5	
0.	620	15.2	12.4	
1.	350	14.0	20.0	
2.	315	13.8	22.0	

gelatin when dry to strip from the support. If, on the other hand, the adhesion is very high between gelatin and the support, drying and the resultant contraction can exert a tremendous force upon the support, which may break or shatter under the strain. Thus, it is possible to shatter glass or pull out slivers from the surface with drying gelatin. A curious example of this occurring with a photographic negative is shown in the illustration. The most satisfactory way of drying gelatin would be to carry out the drying so that the atmosphere was only slightly below saturation at the given temperature. This would mean, however, too slow a procedure in practice, but would give freedom from excessive strain. Practically the chief trouble with drying motion picture film is spotting from mechanical excess of water, which may be avoided by squeegeeing of the surface water at the commencement of drying. Some approach to the ideal drying condition can also be achieved by making the drying counter-current; that is, allowing the film to meet the air current, so that the incoming

dry air meets the nearly dry film, while the outgoing moisture-laden air is meeting the wet film.

Mechanical Troubles Following Swelling and Drying

It appears worth while to list the chief troubles likely to occur from bad conditions during the swelling and drying. The accompanying tabulation is not exhaustive but covers the most important

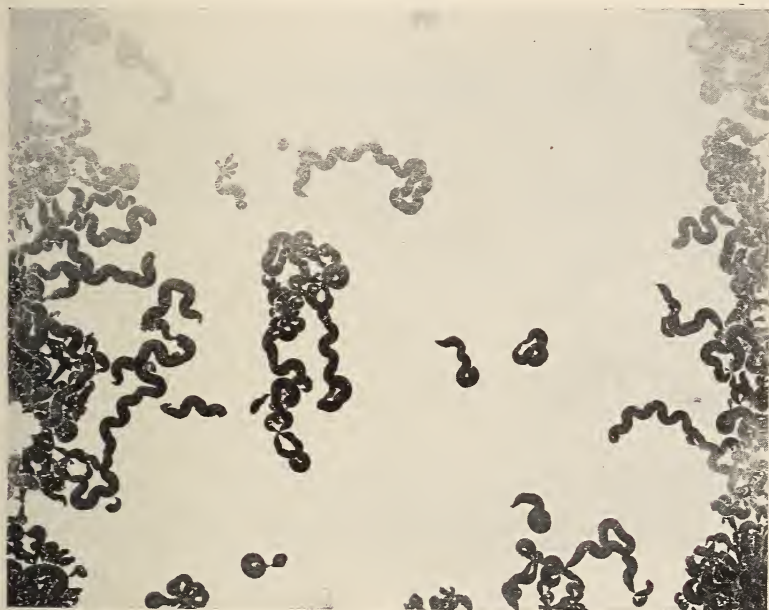


FIG. 11. Glass Stripped by Drying Gelatin.

cases. Wet curl, frilling, and stripping are all possible results of excessive swelling of the gelatin. Dissolving of the emulsion is a trouble likely to occur only in very hot weather but again represents a still more extended conditions of swelling. Finally, reticulation is a

TABLE III

<i>Swelling</i>	<i>Drying</i>
Wet curl	Dry curl
Frilling	Cockle
Stripping	Stripping
Softening and scratching	Melting
Dissolution (Melting)	Scratching
Reticulation	

condition brought about where swelling and deswelling are operating simultaneously, as it were, in the gelatin layer, but not at the same points. This condition can be brought about by simultaneous or successive treatment of the gelatin with softening and hardening, that is, swelling and dehydrating, reagents. A very common cause of reticulation is the use of wash water which is much warmer than the temperature of the processing baths. The action of the warm water in producing reticulation is made more comprehensible by considering

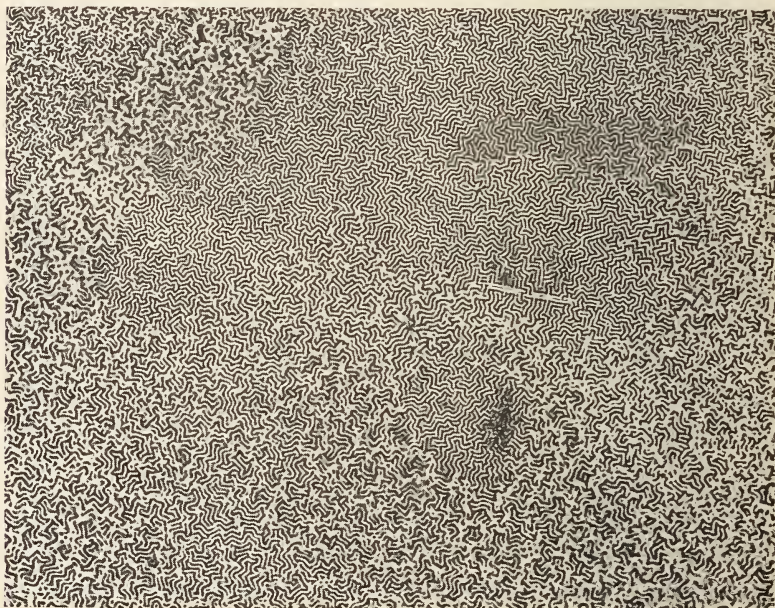


FIG. 12. Reticulation of Gelatin Silver Halide Emulsion (Developed).

the curves in Fig. 3, in which it is shown that water above a certain temperature is actually tending to produce a lateral contraction of gelatin while the total volume is increasing. The use of dehydrating and hardening agents, such as ethyl alcohol and formaldehyde, is also a fertile cause of reticulation.

Reticulation not only involves the production of mechanical relief but also a movement of the particles of the image, which tend to aggregate in the ridges of the pattern or "grain" and to become scantier in the intervening valleys. This is an actual migration of silver particles due to tension, similar to that occurring upon the drying

of moisture spots when the silver particles aggregate in the drying edge. A recent observation of the German colloid chemist Freundlich perhaps throws further light upon this. He has found that in gelatin jellies suspended particles moving in an electric field move through gelatin jellies almost as easily as through water, showing that there is a high degree of mobility of solid particles coated with gelatin within the jelly under certain conditions. This aspect of reticulation is not without importance for the production of graininess in the photo-



FIG. 13. Migration of Silver Particles in Water Spot.

graphic and motion picture image, which is very probably largely enhanced by incipient reticulation.

From the foregoing generalizations we may draw certain conclusions guiding the practice of processing motion picture film. In the first place, it is essential to avoid excessive swelling; that is, swelling of the unlimited type, which means permanent deformation of the gelatin.

The more specific propositions to achieve this are listed below:

1. Use of sufficient neutral salts in the developer to restrain the swelling produced by the alkalinity of the bath.

2. Avoidance of excessive alkalinity or acidity in processing baths.

3. Uniformity of temperature of processing baths and wash waters.

4. Keeping down the temperature as well as possible below a certain limit.

5. Avoiding excessive washing; that is, making the washing efficient so that the material does not remain longer than is necessary.

It is well known that high temperature conditions, such as are obtained in the tropics, impose great difficulties upon the processing of photographic material, and these have been specifically dealt with by J. I. Crabtree.¹ Although rapid drying is not theoretically ideal, practically it is necessary and unobjectionable if precautions are taken to insure uniformity in the drying and absence of spots and patches. Spots of water on the back of the film will of course locally delay the drying and should be removed equally with surplus water on the face. Since the gelatin is generally hardened in processing by the use of combined hardening and fixing baths or by separate hardening baths, a higher temperature of the drying air is possible than with plain gelatin.

DISCUSSION

MR. STEWART: In the motion picture rolls that we use in the Kodak cameras, is the substratum the same as that for motion picture film?

DR. SHEPPARD: As far as I know.

MR. STEWART: If we take ordinary motion picture film and put it under a warm water faucet the gelatin is rapidly removed, whereas with Kodak roll film if you want a piece of clear film support, it is very difficult to wash off the gelatin.

DR. SHEPPARD: The difference is not so much a matter of the nature of the substratum as of the treatment given with a view to the subsequent handling of the film. Motion picture film is usually hardened much more than roll film during processing.

MR. R. C. HUBBARD: In the charts showing the curve of the swelling of gelatin, I believe you used one each at 15°C., 20°, and 25°C; the normal temperature is 19°C. Do you find that the gelatin continues to swell at that temperature?

DR. SHEPPARD: You are just about on the verge of passing from continuous swelling; much above 18 you pass into the unlimited swelling stage.

¹ "The Handling of Motion Picture Film at High Temperatures," by J. I. Crabtree, *Trans. S.M.P.E.*, No. 19 p. 39 (1924).

MR. ISAACS: You recommend, then, a constant temperature for the water, developer, and fixing bath?

DR. SHEPPARD: As near as possible to 18°C.

MR. ISAACS: Would you put any limitation in minutes to the washing time at that temperature?

DR. SHEPPARD: I can't fix a specific limit, but the necessary time for removing excess salts from it is a good time to stop.

MR. BRIEFER: The pH of gelatin in the region of 10 is of little significance in general commercial uses because few products, of which gelatin is a part, are that far on the alkaline side, whereas, in photography it is of the utmost importance. This work of Dr. Sheppard's should convince anyone that in processing film it is not advisable to add alkali or other chemicals to strengthen or energize a spent developing solution without knowing the resultant pH . This abuse is common practice in some laboratories.

If laboratories provided themselves with colorimetric tubes, they could measure whether they were above or below a desired value for fixing and developing baths. I think this would tend to reduce the abuses to which film is subjected in processing.

Another consideration is the drying of film: if excessively dried, the gelatin will not re-absorb a sufficient amount of moisture to restore pliability; some of the injurious effects of drying will persist.

DR. SHEPPARD: I am in hearty agreement with what Mr. Briefer has said. The pH value is of greater importance in dealing with gelatin than temperature, and some way of getting a measure of it is equally important with the use of a thermometer.

With regard to alkalinity, not only do we have swelling changes but at high alkalinity with gelatin there are basic changes which are not reversible. With the pH much above 10, this is true, and I hope that something may be done to introduce the idea of measuring the pH value, probably, as Mr. Briefer suggests, colorimetrically, since chemically this is not possible at present.

MR. CRABTREE: With regard to determining pH values with indicators, is there a dye indicator which will not bleach in the acid fixing bath?

DR. SHEPPARD: I don't know of one. This is a very difficult matter and not possible generally. Certain differences are possible if you work very rapidly. pH values cannot be determined electrometrically in most developers. I agree that this is very important, and we should work on indicator dyes which will stand up in particular

baths. The range over which indicators can be used is also limited in that the gelatin produces what is known as a "protein" error. Gelatin has a buffering action, and you can work with gelatin and acids without buffering the solution, but there is a shift in the indicator point. Fortunately, as far as our own investigations go, it begins to become serious only at very high and low pH 's—3 or 4, which is as acid as any is likely to be, and above. The protein error usually present in developing baths and plain acid solutions is not very serious. I am sorry that we have not definite, accurate methods of determining pH in the acid fixing bath.

MR. CUFFE: I should like to ask relative to the amount of swelling with an 11- and a 3-minute developer. Does this make any particular difference in the quality of the negative?

DR. SHEPPARD: I doubt it; under ordinary conditions, considering that a well balanced developer is used, time will not affect the matter because you have reached the limit of swelling. It would make a difference though if you were starting at higher temperature with a developer not restrained with adequate neutral salts, such as sulphite or sodium sulphate. In this case it would make a great deal of difference.

DR. HICKMAN: Dr. Sheppard has shown some curves which were new to me, for I did not realize that at as high as 25°C. there is a definite swelling limit for gelatin in water. I have an impression, however, gathered admittedly from no text book or published paper, that gelatin passed through a sequence of baths will swell indefinitely. Perhaps Dr. Sheppard will correct me. Suppose gelatin is swollen in substantially pure water to the limit at a definite pH and is then transferred to a strong salt solution which represses swelling. The gelatin should shrink. Suppose, now, it is transferred again to plain water, as at first; then, according to Dr. Sheppard's curves, it should swell again to the plain water limit. I suggest, however, that it will swell much more owing to the osmotic pressure exerted by the salts acquired during the second bath, distending the gel structure as they diffuse away. Speaking photographically, this would mean that a number of varying baths interspersed with plain water rinses, each safe, might in succession swell the gelatin beyond the normal limit and ultimately produce disintegration. I ask the question because if Dr. Sheppard agrees with me, a warning should be sounded against the danger of undue immersion in various toning, intensifying, or baths unless the film is dried between each treatment.

DR. SHEPPARD: That is very interesting. I do not think I have sufficient absolute evidence as to whether previous treatment of this sort would produce this effect, but the effect of each stage produces hysteresis; that is, behavior not possible if the first treatment were not there. Gelatin has an incipient memory and changes its behavior in consequence of its previous action. In general, the less the number of treatments necessary, the better.

Considerable danger is possible by insufficient washing between the alkaline developer and the fixing bath. Apart from developing troubles by the reduction of acidity of the fixing bath and the possibility of dichroic fog by the reduction of silver, it is possible that the upper layer of the gelatin will be completely neutralized and shrink while the lower layer is still swollen; whereas, if the developer is fairly well washed out, this is avoided. Also, there is the possibility that with a strong carbonate solution impregnated in the gelatin, you will generate enough CO_2 to lift up the film, so that it is very desirable to give an adequate rinse between the developing bath and the fixing bath.

MR. BRIEFER: I think some of the dyes could be used satisfactorily because it is not necessary to prolong the experiment; mere comparison with the standard is sufficient.

In connection with Dr. Hickman's point, it may be interesting to investigate the probability. Gelatin in solution or, what amounts to the same thing for the purpose of this statement, swollen gelatin has this characteristic: that with time, the jelly strength declines progressively, while the viscosity may, and usually does, rise at first to a certain maximum. However, when the viscosity begins to decline, the destruction of the gelatin cells appears to begin. On photographic film this effect may show an incipient reticulation. Loss of viscosity is coincident with complete hydrolysis.

OIL SPOTS ON MOTION PICTURE FILM

G. E. MATTHEWS and J. I. CRABTREE*

MOTION picture film may become spotted with mineral oil in one or more of the following ways: (1) in the camera during exposure; (2) during passage of the film through a printer or processing machine; (3) when squeegeeing with a pneumatic squeegee previous to drying; and (4) during drying with compressed air containing atomized oil. If the film becomes spotted with oil previous to processing, the oil acts as a resist and causes uneven development. If the oil has access to the film during drying, the drying of the gelatin is locally retarded and spots similar to moisture markings are produced.¹

Oil spots are also usually present on film after projection, but the nature of these spots is too well known to require elaboration.

The literature contains practically no information relative to spots caused by oil on the surface of film or plate emulsions, although Russell has shown that vapors from mineral oils do not produce any deleterious effects.²

This investigation was undertaken in order to determine the precise nature of the spots produced by mineral oil on various motion picture film emulsions previous to or during processing, to classify typical markings, and to find means for their prevention.

Effect of Oil on Unprocessed Film

The effects of the following factors were studied: (1) the nature of the film emulsion; (2) the nature of the oil; (3) method of application of the oil; (4) order of application of the oil in relation to the exposure; (5) the time elapsing between application of the oil and processing of the film; (6) manipulative treatment of the film after application of the oil; (7) miscellaneous factors such as the quantity of oil applied, the nature of the developer, the method of removal of the excess water before drying, and the time and temperature of drying.

* Communication No. 325 from the Kodak Research Laboratories.

Experimental Procedure

Three kinds of oil were used in the majority of the tests; namely, (1) a non-gumming fine grade (low viscosity) oil, (2) a paraffin base light machine oil, and (3) an asphaltum base light machine oil. These were applied either as fine droplets by means of an atomizer or in large drops from a narrow bore pipette or by means of a fine camel's hair brush. The film samples were flashed (uniformly exposed) either before or after the oil treatment so as to give an even density of about 0.8 to 1.0 on normal development. Processing was accomplished by vertical development in tanks or glass tubes. The Eastman standard MQ motion picture developer (Formula D-16) was used with a development time of 6 to 7 minutes at 65°F. The films were rinsed for 5 to 10 seconds in water, fixed in an acid hardening fixing bath (Eastman Formula F-1) for 10 minutes, washed 15 to 30 minutes, swabbed with cotton, and dried either at room temperature (about 75°F.) before a fan or in a cabinet at 85°F. with an air blast.

Experimental Results

The effects of the above named factors were as follows:

1. *The Nature of the Emulsion.* Four different Eastman motion picture emulsions were tested; namely, par speed negative film, panchromatic film, positive film, and duplicating film. The films were flash exposed previous to the oil treatment. Comparison of the various markings showed no outstanding differences in the types which could be attributed to the specific nature of the emulsion. The spots on duplicating film had slightly thicker indentations around the edge than with the other films but otherwise the markings were similar in appearance.

2. *The Nature of the Oil.* In general, the markings produced by three different oils were very similar. The paraffin base oil formed a spot having an inner gray ring which distinguished it from the spots made by the other two oils. The oil of lowest viscosity tended to spread out more, and the spots formed were not as sharply defined as those produced by the high viscosity oil.

3. *Method of Application of the Oil.* The effect of applying oil in fine droplets with an atomizer or in larger drops with a pipette or brush was merely to produce more small spots with the former treatment if the film was not spooled. When subsequently spooled, the film was usually coated entirely with a thin layer of oil which almost completely prevented development. Small drops carefully applied

with a brush gave clearly defined round spots very closely resembling airbells.³

4. *Order of Application of the Oil in Relation to the Exposure.* Any possible difference in the effects produced by applying the oil previous to exposure as compared with applying the oil after exposure was studied as follows:

Samples of negative and positive film were treated with droplets of oil and (a) flashed immediately and stored in various ways as discussed under (6) below; and (b) stored for 16 hours without flashing and then flashed immediately before developing. Tests were also made by flashing the film before applying the oil and then storing overnight before processing. It was thought that the oil drops might act as a negative and accentuate the markings providing the exposure occurred subsequent to the oil treatment. Examination of the samples confirmed this supposition although the markings were not so clearly defined as might have been expected. Apparently, the oil tended to spread out evenly except in the case of very small droplets which retained their globular form. No difference was noted between the spots produced on films which were exposed immediately after treatment or 16 hours later.

5. *The Time Elapsing Between Application of the Oil and Processing of the Film.* Tests were made with negative film treated with oil after flashing and these were developed (a) immediately; (b) after standing flat or when rolled up overnight; and (c) after storage for 4 weeks when tightly rolled. The spots were defined more clearly according as the time of storage was increased. Film developed immediately after the oil treatment showed splotches and indistinctly defined markings.

6. *Manipulative Treatment of Film after Application of the Oil.* Negative film was flashed, treated with oil, and tested as follows: (a) left stationary in horizontal plane on a table for 16 hours and developed; (b) hung vertically for 16 hours and developed; (c) rolled and stored overnight, and for 4 weeks and then processed (see 5, above). Other variations in handling consisted in flashing both before and after the oil treatment when held in a printing frame under pressure. Very sharply defined spots were formed when the film was treated with small drops and not subsequently disturbed until development. If the film was subsequently disturbed, streakings were produced. With film which was rolled up for a short time a mottled effect was produced, and on long time storage very sharply defined black spots were formed.

7. *Miscellaneous Factors.* With an increase in quantity of applied oil the markings became less clearly defined until a condition was reached, when the oil spread evenly over almost the entire film surface. A thin film of oil on the surface of the developer did not produce any noticeable markings on untreated film, and it is not likely except in extreme cases that enough oil would remain on the surface of the developer to be harmful.

The exact appearance of the spots caused by oil on the film previous to drying was changed very slightly by the method used in removing the excess water before drying, and variations of time and temperature of drying had little influence on the appearance of these spots.

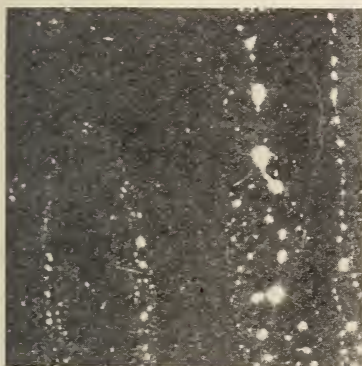


FIG. 1.

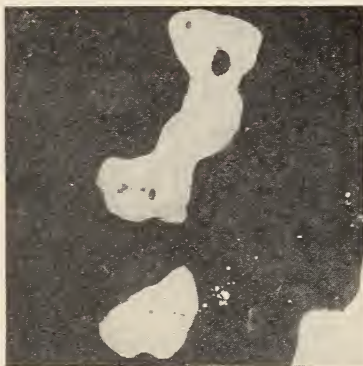


FIG. 2.

Classification of Oil Markings

In the preparation of the following examples an excess of oil over that found usually in practice was placed on the film. The size of the markings is, therefore, somewhat exaggerated although their general appearance and contour is typically representative:

Fig. 1. Chain of Small Gray Spots. These chain-like groups of markings represent the most familiar type of spot caused by oil. They were produced by splashing the film with fine droplets of oil and then spooling or winding the film, thus subjecting the droplets to compression.

Fig. 2. Irregular Light Gray Areas. This represents a common type of marking found on both positive and negative film which has been wound loosely and stored for 16 to 24 hours. It appears as an irregular patch of density lighter than the surrounding area and is

probably a result of the oil spreading evenly over the area as a very thin film and retarding development.

Fig. 3. Mottled Areas. This is another effect produced on both negative and positive film as a result of the access of fine droplets of oil previous to spooling tightly.

Fig. 4. Black Spots and Black Spots with White Centers. The black spots are either the result of a fogging action of the oil on the film emulsion or they are moisture spots.¹ The circular white centers

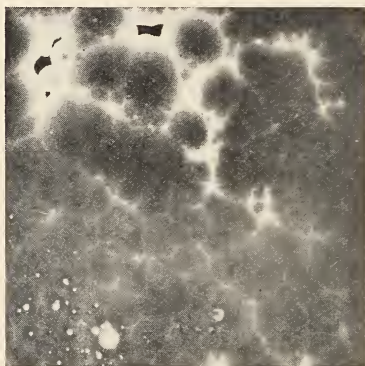


FIG. 3.

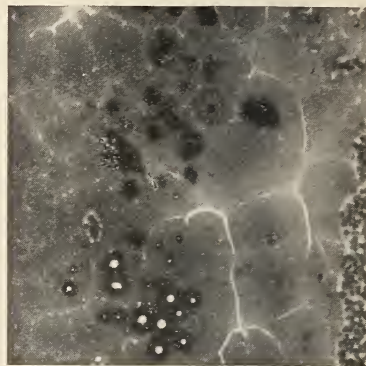


FIG. 4.

which are typical of some of the black spots were probably caused by airbells clinging to the film during development. In a previous paper it was shown that a greasy or oil covered emulsion has a maximum tendency to accumulate airbells during development.³

The figure shows also the mottled effect illustrated in Fig. 3 as well as a curious stippled area along one edge of the film.

Fig. 5. Stippled Stream-Line Effects. These markings consist of tiny white spots distributed as lines or streamers producing a stippled effect. The stream-lines were probably a result of passing the hand over the film surface previous to or during the initial stages of development.

Methods of Removing Oil from Unprocessed Motion Picture Film

Obviously the only way to prevent the formation of oil markings is to remove the oil immediately after its application. Most mineral oils are soluble in certain organic solvents, but they cannot be saponified with a solution of an alkali. It was considered, however, that

treatment with weak alkalis which emulsify the oils might be a satisfactory method for removing them.

The effect of attempting to remove oil from the film emulsion surface by manual methods was first studied. Short lengths of negative film were treated with oil after exposure and then squeegeed with a rubber squeegee. Other lengths were polished with a cloth

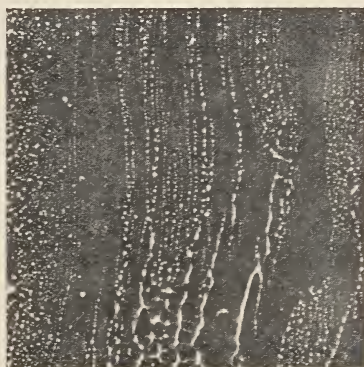


FIG. 5.

after squeegeeing. The squeegeeing treatment diminished the intensity of the markings but did not eliminate them. However, by squeegeeing and then polishing, the developed film was almost entirely free from markings.

Two methods of chemical treatment were also tried; namely, (1) emulsification with sodium carbonate solution previous to development, and (2) dissolution using carbon tetrachloride and benzene. Film strips were immersed for 5 minutes with agitation at 1 minute intervals in a 10% sodium carbonate solution, rinsed 5 seconds, and then developed in the usual way. The experiment was tried also of developing the film in a strongly caustic developer (Eastman Formula D-9) with the idea that the alkali in the developer might act as an effective emulsification agent. This treatment, however, was not effective.

In the series of tests with the organic solvents, strips of film treated with oil after flashing and after storing horizontally overnight were bathed for 2 minutes in the solvents, squeegeed, dried before a fan, and developed as usual. The results of the tests are given in Table I.

TABLE I.

<i>Treatment</i>	<i>Appearance</i>
None	Many irregular white spots
10% sodium carbonate	Few small white spots resembling airbells
Caustic Developer	Many irregular white spots
Carbon tetrachloride	Few pin-like markings—probably airbells
Benzene	No markings

A great many tests were made with the carbonate treatment both immediately after the oil treatment and with oil treated film stored overnight. The effect of flashing a film either before or after oil treatment was studied in each of the above series of tests. In some instances the carbonate treatment was quite effective, but in all cases where the exposure was made after applying the oil to the film, it was obviously impossible to prevent the spots. Although mineral oil is not saponified by sodium carbonate, apparently in some cases the oil is emulsified to such an extent as to allow partial penetration of the developer. Check tests indicated that the solvent treatment did not tend to produce fog or streakings or retard development.

Removal of Airbells by Brushing

After examination of a great many samples of oil treated film which were bathed in a sodium carbonate solution before development, it was concluded that in most cases when small white spots are produced at the center of darker areas, such spots are the result of the presence of airbells during development. In order to confirm this supposition, the surface of the film was gently brushed during the first stages of development in order to dislodge any airbells.³ The results are shown in Figs. 6, 7, and 8. Fig. 6 shows negative film which was spotted with oil and developed without further treatment. Fig. 7 shows a portion of the same film sample as Fig. 6 which was bathed for 5 minutes in 10% sodium carbonate, rinsed 5 seconds, and then developed. It shows the partial emulsification effect of the carbonate although airbells are still present. The film shown in Fig. 8 was bathed in carbonate as described and then brushed during the initial stages of development. The brushing treatment removed the airbells but an irregular nucleus remained.

Effect of Oil on Film During Drying

After processed motion picture film has been washed, it may be splashed accidentally with oil previous to or during drying, and characteristic markings may be formed. The most common cause of oil getting on the film during drying is the incomplete removal of

atomized oil in the compressed air used for squeegeeing the film on continuous processing machines. To determine the nature of such markings the following tests were made:



FIG. 6.



FIG. 7.

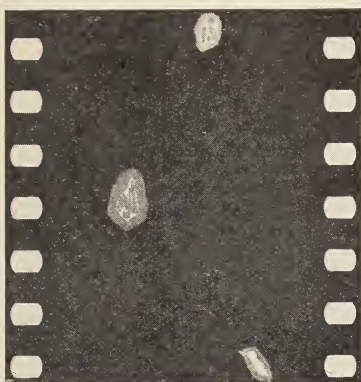


FIG. 8.

Strips of flashed positive and negative film were processed as usual, swabbed free from excess water with cotton and then treated with two samples of oil. The films were then placed in a horizontal position and dried at 100°F. The two characteristic markings produced are shown in Figs. 9 and 10. Fig. 9 shows the effect of an oil drop which was not disturbed after being placed on the film. Strains produced by retarded drying of the gelatin beneath the oil spot probably caused the silver particles to wander as described by Sheppard and Elliott,⁴ and Ross,⁵ the typical dark ring surrounding the spot being formed.

Fig. 10 is a variation of Fig. 9. It shows the characteristic dark boundary and lighter central portion and was formed by a quantity of oil too large to form a droplet and which therefore became unevenly distributed over the film surface.



FIG. 9.



FIG. 10.

There is no method known of preventing the formation of spots on film during drying after the oil has once been applied to the film. If the presence of oil on the film is a result of oil in the compressed air supply, a suitable oil filter such as the one described by Crabtree and Ives should be installed.⁶

Effect of Oil on Processed Negatives

White spots on positive prints are often produced by dark brown spots of dirty oil on the negative. Freshly applied oil on the emulsion side of the negative will also offset onto the positive in the printer. If applied to the base side, the oil will offset onto the emulsion side when the negative is spooled, and in turn this will offset onto the positive during printing and act as a resist during development. Fig. 11 shows typical spots on a print from a processed negative containing oil on the emulsion surface.

Summary and Practical Suggestions

The presence of oil on motion picture film previous to development or during drying produces spots or markings on the processed film. The nature of the markings produced is independent of the nature of the emulsion or the kind of oil commonly used on cameras, printers, and processing machines.

The spots are more pronounced if the film is exposed after it is coated with oil because the oil acts as a negative and produces a

printed image. The spots are less pronounced if access of the oil is subsequent to the exposure. The manipulative treatment which the film received after access of the oil and previous to processing and the



FIG. 11. Showing Appearance of Print from Oil-spotted Negative.

time elapsing between access of the oil and processing greatly influences the appearance of the markings.

The shape of the markings produced is obviously analogous to the contour of the globules or smears of oil producing them. In the case of unexposed film certain types of oil produce a fogging effect and cause dark markings if left on the film several weeks, but with exposed film the oil acts as a resist during development and produces a spot or patch of lighter density than the surrounding areas. Also,

since a greasy emulsion surface has a high propensity to accumulate airbells on immersion in a developer,³ many oil spots have circular white centers caused by the protective action of such airbells. The airbells may be dislodged by gently brushing the surface of the film during the initial stages of development, but this is only possible when film is developed on a continuous processing machine.

The presence of oil on the emulsion side of motion picture film can usually be confirmed by placing the film for a few seconds in water at a temperature of about 100°F. Any drops or smears of oil will retard the swelling of the gelatin and will be visible in bas-relief on viewing the surface of the film by reflected light.

The most satisfactory method of eliminating oil from the surface of motion picture film and therefore of preventing the formation of oil spots is to immerse the film in a bath of benzene or carbon tetrachloride, squeegee, and dry thoroughly previous to development. Such a treatment can be accomplished successfully with a film cleaning machine of the Dworsky type.^{7,8}

The access of oil to film can usually be prevented by care in the lubrication of machinery such as cameras, printers, and processing machines. Sprockets, idlers, and spindles should be oiled whenever possible by removing the sprocket or idler from the spindle and greasing the spindle with an oily cloth rather than by applying oil with an oil can. The arrangement of the lubrication of motion picture machinery to prevent the possibility of access of oil to the film should be given the most careful consideration by designers of such machinery.

Acknowledgment

The authors are indebted to Edwin O. Wiig for his assistance in part of the experimental work.

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⁷ "Cleaning Motion Picture Film" by T. Faulkner, T. Soc. M. P. Eng. X, No. 25, 117, (1926).

⁸ "Cleaning Liquids for Motion Picture Film" by J. I. Crabtree and H. C. Carlton, T. Soc. M. P. Eng. XI, No. 30, 277, (1927).

DISCUSSION

MR. ROSS: I should like to ask if the oil was chemically analyzed before use. Dark spots might be caused by foreign matter, such as sulphur compounds which are not removed by ordinary refining.

MR. MATTHEWS: No analysis was made; we chose oils typical of those used in cameras or processing machines. Sulphur compounds, if present, would probably produce a fogging effect but hardly a desensitizing action such as was so often observed in the case of most of the spots. The oil merely prevents access of the developer at those points. On long time keeping tests traces of sulphur if present might produce black spots.

MR. CRABTREE: With regard to the fogging action of the oil, I don't know of any chemical test which is sufficiently delicate to test for quantities of sulphur which might produce fog. An infinitesimal amount, almost impossible to detect by chemical tests, would be apt to produce fog. The black spots were most probably caused by moisture.

DR. HICKMAN: I should like to make a tentative comment on the sulphur business. Up to a year ago, it was being assumed that sulphur could only be a fogging agent. During the year there have been publications showing that sulphur can desensitize as well as sensitize. It can desensitize and destroy the latent image because it can result in the silver liberated during latent image formation. Mr. Crabtree gave the key to this when he said the moisture content might be different. In one case we would get sulphur fog and in the other case sulphur desensitizing. I think the only way we can test the matter is to leave the oil in contact for months with a polished mercury or copper surface; the slightest visible tarnish would indicate the presence of more than enough sulphur to cause fog on the latent image.

MR. R. C. HUBBARD: With regard to filters, the best possible method of getting oil out of the air is to run it through a cooling coil.

MR. CRABTREE: How will that remove the oil?

MR. HUBBARD: It seems that oil and water in the air are mixed as an emulsion, and when you abstract the water, the oil goes with it. My experience with the filters is that some oil will be carried through if the air is warm.

A TRIAL AND ERROR METHOD OF PREPARING A MOTION PICTURE SENSITOMETER TABLET

C. E. IVES AND J. I. CRABTREE*

In motion picture film laboratories sensitometers or timing machines frequently are employed for accurately determining the printing exposure required by the various scenes of a negative. One type of sensitometer^{1,2} consists essentially of a printing machine which exposes the negative onto positive film through a tablet made of areas of uniform density (each the size of a single motion picture frame) and of increasing density from one end of the tablet to the other. The density of the various steps of the tablet is such that with the proper time of exposure the positive film receives exposures over a distance of nine or more frames equivalent to those given by the various light steps on the printer. By examination of the developed sensitometer strip, the correctly exposed frame is then chosen by inspection and a number on the particular frame indicates the correct printer exposure (Fig. 1).

A method of preparing such a sensitometer tablet has been published¹ previously but this involves a knowledge of sensitometry and the use of a densitometer. Since few motion picture laboratories are equipped for such work, a simpler method of preparing a sensitometer tablet will be described.

The preparation of the tablet involves the following operations:

1. Testing the printer for uniformity of exposure.
2. Determination of the relation between the exposures given by the various light change steps on the printer.
3. Determination of the maximum and minimum density steps of the tablet.
4. Tentative choice of intermediate tablet steps.
5. Comparison of each tablet step with the corresponding printer step and final adjustment of the tablet.
6. Testing the sensitometer.

1. Testing the Printer for Uniformity of Exposure

The first step necessary is to make certain that the exposure given by the printer is uniform both throughout the area of a single

* Communication No. 324 from the Kodak Research Laboratories.

frame, and from frame to frame in the case of a step printer, or throughout the length and breadth of the film with a continuous printer.

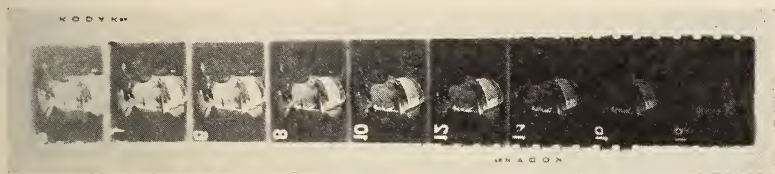


FIG. 1. A Typical Developed Sensitometer Test Strip.

A satisfactory test is made by printing a flash (uniform) exposure on about two feet of motion picture film by running through the printer without a negative. The development should be that given for normal quality prints and the exposure should be such that the density is between 0.3 and 1.0. The degree of blackness of a developed photographic film is specified numerically in terms of density. As a guide, the filament of a 40-watt nitrogen tungsten is just invisible through five thickness of uniformly exposed and developed film each having a density of 0.75. These should be held close to the eye.

The flashed film should be examined in front of a uniformly well illuminated sheet of opal glass by cutting the strips and bringing together two cut edges from different parts of the films to be compared. If the results of this test indicate variations in illumination over the printing aperture, the defect must be corrected. Frequently such unevenness in illumination is due to the use of a wrong type of lamp or to reflections from the inside of the lamphouse or aperture tunnel. Trouble from reflections can be overcome by the use of a black matte varnish. Variations in density throughout the length (except near the start and stop) are due to fluctuations in illumination or faulty mechanical action. All of these should be corrected before starting to prepare the sensitometer tablet. In the tests described above great care must be exercised to prevent unevenness of development.

The range of exposure from the least to the greatest given by the printer should be adjusted as follows: The lowest light change step should be so adjusted that it gives just sufficient exposure to print the best positive from a negative which is so thin that the objects depicted can just be distinguished in the positive. With this printer setting, the printer light change step giving the greatest

exposure should take care of badly over-exposed negatives. As a further check, an average good negative should require a light change setting near the midpoint of the range. Eighteen or twenty steps between the extreme exposures given by the light change are usually sufficient.

2. Determination of the Relation Between the Exposures Given by the Various Light Change Steps on the Printer

If a photographic emulsion is given a series of exposures increasing regularly from one to another, the scale of densities produced on development will show a regular relation to the exposures producing them over a considerable range of exposure. The exposures must be chosen, of course, to suit the sensitiveness of the emulsion. The relation between the exposures given by the several steps of a motion picture printer can best be determined photographically.

Consider a tablet which gives a set of exposures equal to those given by the printer at each light change step. The densities of the tablet can be represented graphically (Fig. 2), the height of the rectangles being proportional to the density of the particular tablet steps.

If three samples of film are printed through this tablet, giving equal exposures, and the prints developed for different times, the prints also can be represented graphically (see I., II., and III., in Fig. 2)

The density difference between tablet steps A and B (tablet in Fig. 2) is (a) and between B and C is (b), etc. The densities printed from these are A_1, B_1, C_1, D_1 , for the short development; A_2, B_2 , etc., for the medium development time; and A_3, B_3 , etc., for the long development time. The difference in density between A_1 and B_1 is a_1 , etc. It will be seen that these density differences increase with increasing development time and that a_2, b_2, c_2 , are equal, respectively, to a, b, c , but that a_1, b_1, c_1 , are less than a, b, c , respectively; and a_3, b_3, c_3 , are greater, respectively.

From this it is seen that by suitable development a series of densities can be produced by exposing on the printer which will have density differences from step to step equal to the density differences between the corresponding steps of a tablet which is to be made to match the printer. This is true only within certain limits determined by the nature of the film emulsion. These strips of increasing density

made on the printer will serve as a guide in assembling the required tablet.

A definite technique must be followed in order to obtain the required development, as will be described below.

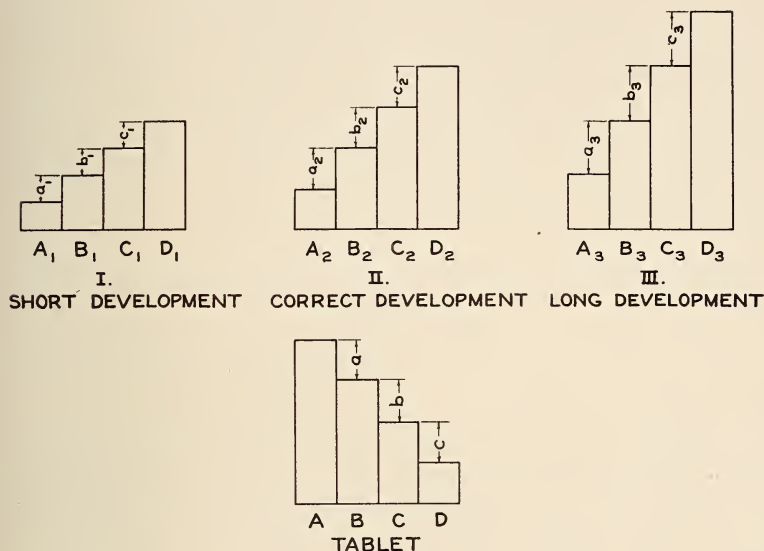


FIG. 2.

Experimental

A series of flash exposures should be made on positive film about two feet of film being run at each exposure step on the printer. During this procedure it is necessary to maintain the line voltage constant. All of the strips should be developed simultaneously. The time of development which gives the relationship stated above with Eastman motion picture positive film is $3\frac{1}{2}$ minutes at 65°F . in the Eastman MQ developer (Formula D-16) diluted with an equal volume of water. The rack should be moved continuously throughout development. This can be insured by causing the top of the rack to describe a rectangular path under the surface of the developer and by lifting the rack one-half way out of the tank once each minute after the first minute of development.³

The set of flash exposures resulting will serve as a rough measure of the relative exposure given by the printer steps, and a casual examination will reveal any gross irregularities, if not already noticed,

in the relations existing between the different steps. Such irregularities should be corrected by suitable modification of the light change device if experience has shown that they are inconvenient.

Motion picture light changes are designed usually to give exposures which increase proportionately from one step to the next, so that the densities produced as described above differ by a constant density difference. Any non-uniformity is readily noticeable and can be tested for by choosing a sample of film of a light uniform density, which, when superimposed over any one of the printer light change test densities, makes a combined density equal to that produced at the next higher printer step. If this process is applied to each step in succession, any irregularities will be found.

3. Determination of the Maximum and Minimum Density Steps of the Tablet

For a printer of ordinary range having eighteen or twenty exposure steps varying from 2.5 to 250 candle meter seconds, it will be sufficient to have every second printer step represented on the tablet. The separate flashed motion picture film densities composing the tablet can be mounted on a sheet of clear glass by securing their edges with lantern slide binding tape and covering the whole with a sheet of thin Kodaloid. Small opaque paper numbers fastened in the corner of each frame will assist in identifying the steps.

For use in building the tablet, it is necessary to prepare a stock of film having densities ranging by very small differences from clear film to a density nearly as high as the maximum density produced in the light change tests. The low densities can be prepared by running a strip of motion picture positive film through the printer while the light change is set at the setting of the least exposure and then cutting down the lamp current by an external resistance. Higher densities of varying magnitude can be made by using the regular printer settings and varying either the current supply or the time of development of the strips thus flashed.

If the lowest and highest tablet densities are chosen and tested first, it will be very much easier to select the intermediate ones.

With a printer having twenty light change settings, the steps No. 2 and No. 20 must be considered first. The printer step giving the greatest exposure (No. 20) should be represented in the tablet by a clear piece of positive film; that is, one which has been developed and fixed without previous exposure. To represent the No. 2 step

a density sample should be chosen which is equal approximately, to the heaviest density (No. 20) produced in the printer light change test minus the lightest but one (No. 2). These should be mounted temporarily in the tablet.

The correct exposure conditions in the sensitometer should then be chosen by making flash exposures through the tablet with the illumination regulated to give varying intensities and, by flashing a part of the same strip of film on the printer, set at step No. 20. If the sensitometer exposure is correct, the No. 20 step on the printer and sensitometer will produce equal densities when the film strips are developed together under the conditions stated previously. If at this exposure the density given by the No. 2 step of the sensitometer is too low, the film sample in the tablet should be replaced by another of less density and vice versa. When the correct density of this tablet step No. 2 is found, density samples for the eight intermediate steps can be chosen.

4. Tentative Choice of Intermediate Tablet Steps

At this point the set of flash densities given by the printer is consulted for the purpose of estimating an average exposure difference and for noting irregularities at any point.

Ordinarily the exposure differences are such as to produce equal density differences. This will be noted by the fact that the same density superimposed over any one of the flash densities made in the printer tests makes a combined density equal to that produced by the next higher printer step. If such is the case, it will be convenient to construct a trial tablet of uniform density gradient. By selecting a suitable density sample which will be equal to the average density difference between successive tablet steps, a piece of film can be selected for each tablet step by matching with the next lower step over which has been placed the density difference sample. A few trials may be necessary to find the correct average density difference, but this can be checked by placing, one over another, as many thicknesses of this density as the number minus one of the steps in the tablet, when their total density will be equal approximately to that of the tablet step previously chosen. Thus, a tentative tablet is completed.

If the differences in density between the test samples exposed at consecutive light change steps on the printer are unequal, it will be necessary to deviate accordingly from the regularity of increase.

in density from one tablet step to the next. If the printer test exposures have been developed as described, the density difference between any two of them will be equal to the density difference between the corresponding tablet steps. (This may not hold if the range of exposures given by the printer is much greater than usual or if the range is extremely high or low.)

5. Comparison of each Tablet Step with the Corresponding Printer Step and Final Adjustment of the Tablet

The final procedure is to make such alterations in the trial tablet as are found necessary to bring about perfect agreement with the printer. In matching the printer and sensitometer at any particular step, it is best to make actual prints from a uniform, good quality negative which is known to be suitable for printing at that particular step. Variations in density from frame to frame of the negative will cause no trouble if the precaution is taken to compare prints from the same frame as printed on the sensitometer and printer. This is facilitated by putting characteristic scratch marks in one corner of each frame. Only about two feet of negative are required for this purpose. To be satisfactory, these comparison strips must be developed not only together but to a sufficient degree of contrast to make a print of good quality. In this manner, one step at a time is brought into agreement with the printer with the use in every case of a proper negative.

The intensity of illumination of the tablet should permit an exposure of at least six seconds for manual operation and should be adjusted so that this is the case when the printer and sensitometer agree.

For a sensitometer in which the exposure is timed by a mechanical means, the time should be equal as nearly as possible to the exposure time given by the printer. If the timing involves turning on and off the current of the lamp, this time should be sufficiently long so that the time required for the lamp to reach full brilliance is only a small fraction of the total time of exposure.

6. Testing the Sensitometer

From time to time it is necessary to test the sensitometer to find out if it is in good agreement with the printer. Since changing the time of exposure is, in the case of most sensitometers, exceedingly impractical and always undesirable, it is necessary to adjust the

light intensity to the proper value. This is done by varying the sensitometer lamp voltage by means of a rheostat.

The complete procedure is as follows: A print from a negative is made on the printing machine at some definite setting on the light change board as, for instance, at No. 20. The negative chosen must be suitable for printing at the step chosen. On another portion of the same strip of film a series of test exposures is then made on the sensitometer with the negative in position with various lamp voltages. These test exposures and those made on the printer are developed together for a time necessary to give a positive of good quality, care being taken that all are developed to the same extent. The particular lamp voltage which gives a print at step No. 20 on the tablet which matches the print at step No. 20 on the printer is the correct value at which to operate the sensitometer lamp. Each frame of the negative should be marked as described in Section 5.

References

¹ "A New Sensitometer for the Determination of Exposures in Positive Printing" by L. A. Jones and J. I. Crabtree, *Trans. Soc. M. P. Eng.*, 15, 89, 1922.

² "Improvements in Motion Picture Laboratory Apparatus" by J. I. Crabtree and C. E. Ives, *Trans. Soc. M. P. Eng.*, 18, 161, 1924.

³ "The Development of Motion Picture Film by the Reel and Tank Systems" by J. I. Crabtree, *Trans. Soc. M. P. Eng.*, 16, 163, 1923.

DISCUSSION

MR. BEGGS: In your machine do you use gas-filled lamps or vacuum lamps?

MR. IVES: We operate a 110-volt gas filled lamp at 90 volts so as to prolong its life.

MR. COFFMAN: It seems to me there is a need for a good commercial sensitometer available to laboratories. I think sensitometry would be more generally practiced if one were available. Heretofore, anyone wanting a sensitometer has had to go to the time and expense of building one, which I think has held back the general adoption of machine timing in the laboratories.

MR. CRABTREE: The Cinex timing machine made in Hollywood is available. The principle is slightly different from that just described. The light source is constant, and the exposure is varied by diaphragms. It works on the same principle as the H & D shutter. It consists of a series of openings in a cylinder which rotates over the aperture

before which the film is placed. The width of the aperture and the relative times of exposures can be adjusted to match the printer.

PRESIDENT COOK: Is the sensitometer described several years ago by one of the research laboratory men of the Kodak Company available commercially?

MR. CRABTREE: No, it is not available commercially. It was simply an experimental model. Mr. Ives and I have described a semi-automatic sensitometer which any carpenter with a little electrical knowledge can construct. The great difficulty in the adoption of this type of sensitometer has been the preparation of the tablet. The only object of giving this paper was to explain how a laboratory man could prepare one himself. It is a very difficult problem to make a tablet to match a machine remote from Rochester. It is necessary to have access to the machine to get a tablet to match it.

MR. R. C. HUBBARD: With regard to the Cinex machine, you do get a slightly different quality due to the focal plane shutter used in this type of sensitometer than in the type just described.

PRESIDENT COOK: It would seem that a graduated sensitometer tablet of this sort, as described here and as described previously in the machine that you used, would be better adapted for a printing machine using an electrical light control than a diaphragmatic control.

MR. CRABTREE: I don't think it would make the slightest difference provided the sensitometer was adjusted to the printer.

PRESIDENT COOK: The element of the actinic value of the light under rheostatic control complicates the matter.

MR. HUBBARD: There is a perceptible difference in printing lights; that is, control with the rheostat changes the color of the light, and emulsions are sensitive to variations in color. You would find that this would affect the quality of the print; that has been my experience.

PRESIDENT COOK: That was what I was trying to bring out, but Mr. Crabtree says that would not have any effect.

MR. CRABTREE: With regard to the effect of the change in color of the light of the printer lamp with change of voltage, it is, of course, well known that the contrast of an image is affected by the wave-length of the light used to produce it. In the case of Eastman Duplicating Film, we control contrast by the use of a violet filter which reduces contrast. However, this contrast variation is only

appreciable when the emulsion used contains a yellow dye such as is present in the Duplicating Film. With ordinary positive film, the change in image contrast resulting from printing with a high wattage lamp at low voltage (yellowish light) and at higher voltage (violet light) is of little or no moment in practice with regular positive film. It should be remembered that since the various densities of the tablet are neutral in color and therefore non-selective, they transmit light of all colors in the same proportion.

The tablet should, of course, be adjusted to the printer *with a given lamp*. A tablet which works with a 60-watt lamp will not work at all with a printer fitted with a 200-watt lamp when the same rheostatic control is used in both cases.

MR. EMSLIE: Would this work successfully with the Duplicating Film?

MR. CRABTREE: It would work with any stock. Duplicating Film is slower than regular positive film, so that a stronger lamp or longer exposure would be needed.

MICRO-CINEMA IN MEDICAL RESEARCH

BY HEINZ ROSENBERGER*

MICRO-CINEMA has been used chiefly for the demonstration of microscopic phenomena before an audience. The advantage of the motion picture over a practical microscopic demonstration is obvious. Comparatively little use, however, has been made of the micro-cinema in pure research work for the study of happenings in the microscopic world.

There are great possibilities in the use of the motion picture camera as an apparatus for making photographic records of actions which take place under the microscope but which are so slow that the human eye cannot perceive them. These actions are more or less accelerated on the screen if the pictures are taken at a rate of less than 16 per second and then projected at 16 per second, the usual rate of projection.

For about four years, the micro-cinema has been used at the Rockefeller Institute for Medical Research for the making of film records of living cells. The importance of the study of cells, for instance of human and animal tissue, is easily understood when one realizes that the human body is built up of billions of cells, which may be considered the bricks of our system. Many recent discoveries in medicine have been made by investigating in detail with the microscope the functions of the different cells which constitute an organ, rather than by studying the entire organ. A cell is considered an individuum in itself.

Many important facts have been revealed by means of the micro-cinema at the Institute. The following examples are from work done in the Division of Experimental Surgery by Drs. Alexis Carrel, A. H. Ebeling, and the author:

The growth of cultures of various animal tissues was actually observed, cell divisions were analyzed, and many cases of phagocytosis studied.

It was found that the various white blood corpuscles, for instance lymphocytes and macrophages, show marked differences in the character of their movements (Fig. 1).

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The so-called pseudopods of the various white blood corpuscles are not threads, as is generally accepted by the medical world, but the folds of an undulating membrane which surrounds the cell (Fig. 2).

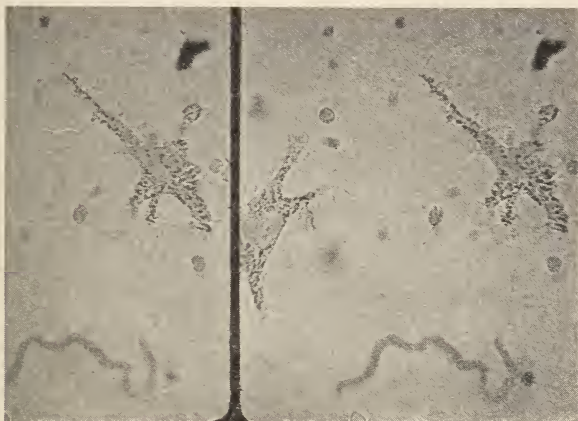


FIG. 1—White blood corpuscles (giant cells) take up smaller cells (lymphocytes).

The action of malignant cells upon normal cells was the subject of many experiments (very important for the study of cancer). The action of x-rays upon normal and malignant tissue was also studied.

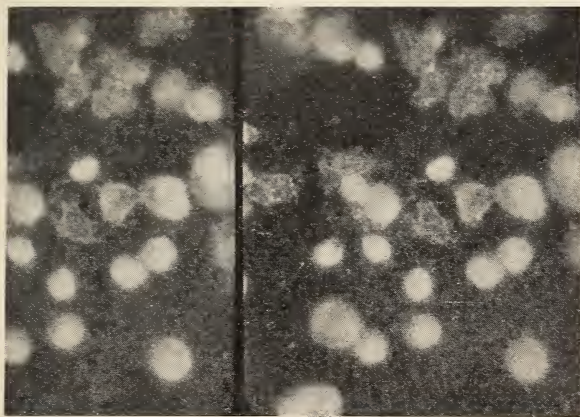


FIG. 2—Culture of white blood corpuscles, just removed from the blood. Dark Field illumination.

Many micro-cinema records of growing nerves (axis cylinders) have been made. This was also a very difficult photographic problem.

Another field where micro-cinema has proved an aid in research work is bacteriology. A film record was made in collaboration with Dr. J. Bronfenbrenner and his co-workers of the growth of a culture of

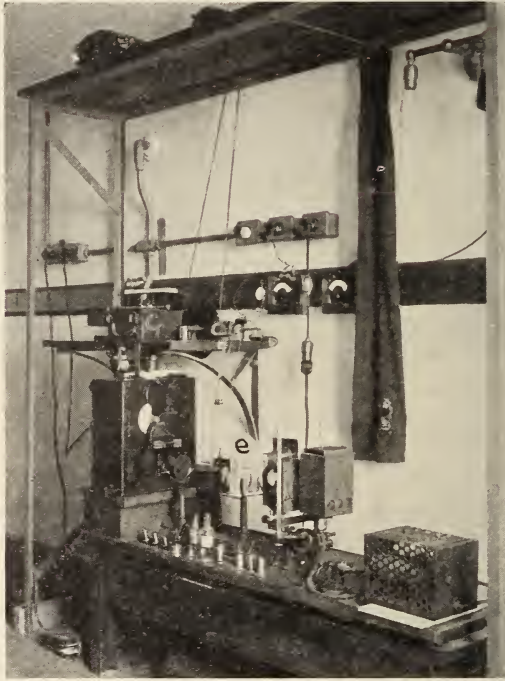


FIG. 3—Micro-Cinema Model 1923.

Bacterium coli and its destruction by bacteriophage. In this study the disappearing of single cells could be observed.

In colloid chemistry micro-cinema has been used for recording the so called Brownian movement of ultra-microscopic particles.

The application of micro-cinema to examinations of the blood of patients will be explained later.

The Micro-Cinema Apparatus

The apparatus used for micro-cinema work is somewhat specialized for the different subjects to be taken, the principal parts being the microscope *a* with the source of light *b* and optical bench on one

table, the camera *c* with the driving mechanism, timer *d*, and revolving shutter *e* on the other table. These two sets are entirely separate from each other in order to prevent the transmission of vibration of

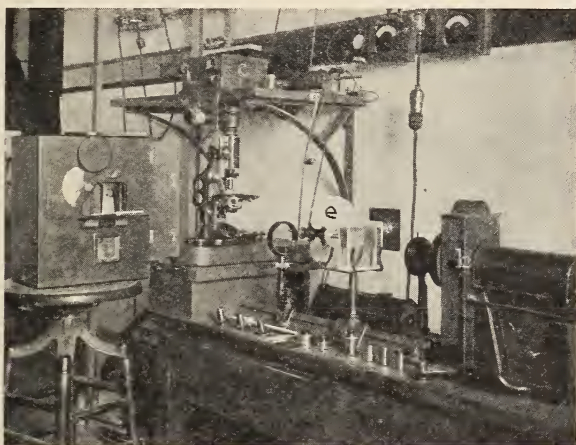


FIG. 4—Micro-cinema (Microscope cover removed).

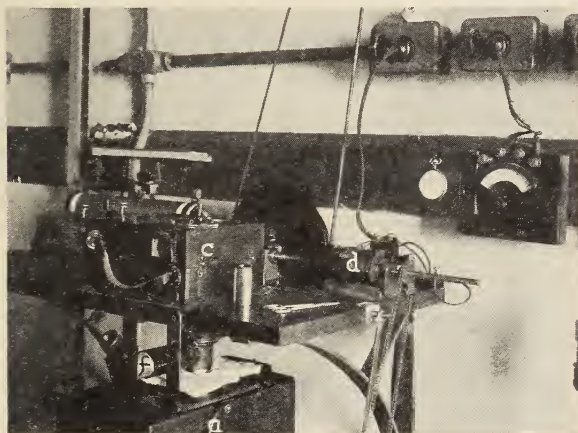


FIG. 5—Camera and timer.

motor and camera. For the same reason the motor is placed as far from the apparatus as is practically possible. With high magnifications, the prevention of vibration becomes quite a difficult problem and has to be reckoned with by selecting a proper room for the laboratory.

The microscope used has a wide tube to prevent reflections inside, which otherwise would fog the film. A mechanical stage is practically a necessity. For the higher temperatures, which are needed with tissue cultures, the microscope is placed inside an incubator with a thermostatic heating unit (Fig. 6). Doors and screw extensions allow an easy handling (focusing) of the microscope. When working with high magnifications an even temperature must be

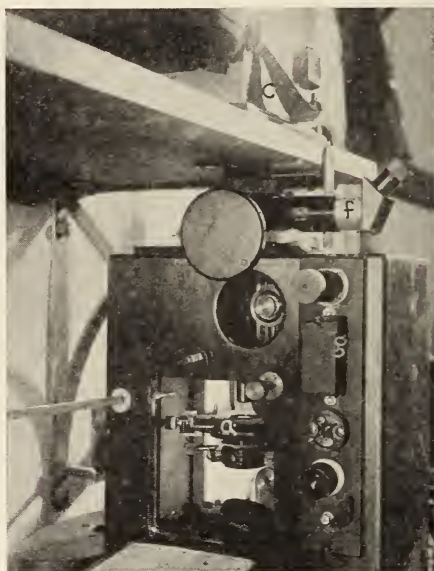


FIG. 6—Microscope in incubator.

maintained. The slightest changes would cause an expansion or contraction of the preparation or the microscope and make it very difficult to keep the subject in focus for any length of time.

The amount of light necessary for exposure depends upon the frequency of pictures taken per minute or second and upon the magnification employed. For long intervals (one exposure every 2 to 45 seconds), an incandescent lamp is used; for shorter intervals, a "Pointolite;" and for the shortest exposures (16 pictures or more per second) (especially with dark field illumination and ultra-microscopy), a high intensity arc lamp is employed.

Almost every microscopic preparation, especially those of living tissue cultures and bacteria, is more or less sensitive to light and

excessive heat. The latter is practically eliminated by a heat absorbing filter (acidified copper sulphate). The light has to be cut down as much as possible, transmitting through the preparation only as much as is necessary for the right exposure. This is done by cutting off the beam of light while the frame in the camera is changing for a new exposure and by allowing it to pass freely when the film is in



FIG. 7—Apparatus for taking motion pictures of human capillaries (capillarograph).

position to be exposed. For long intervals between exposures, the current for the incandescent lamp is switched on and off by the automatic timer connected with the camera drive. For higher frequencies (and when an arc lamp or Pointolite is used), a revolving shutter with adjustable sectors is employed.

The camera (Fig. 5) is of very short design, being only 90 mm. high, and therefore very convenient for focusing control. A built-in magnifier shows the image enlarged on the back of the film.

With comparatively low-powered lenses, an observation piece (system of Dr. Siedentopf) attached to the microscope is used. This enables the operator to observe the subject conveniently while the picture is being taken. The main part of the observation piece is a

cube consisting of two prisms, one of which is slightly silvered, cemented together and thus forming a 45 degree mirror, which is 95% transparent. The rest of the rays (5%) are thrown into the observation piece.

For taking very delicate structures of tissue cells under high magnification, the observation piece could not be used because the proper resolution could not be obtained, and a small camera in place of the moving picture camera was employed for focusing.

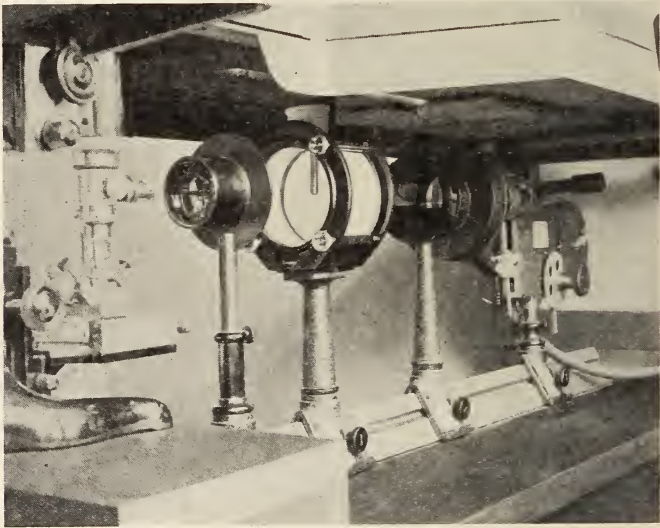


FIG. 8—Optical bench of the capillarograph.

When taking two or more exposures per second, it has been found useful to work the motor of the camera by means of a foot switch. Thus both hands can be used for focusing the microscope and locating the subject, etc.

Special care must be observed in making the preparations for micro-cinema work. Ordinary slides as commonly used in microscopy cannot be used for living cultures on account of the lack of oxygen between slide and cover glass. It has been found that a chamber formed by a perforated slide with cover glasses on either side is more suitable for this work. A culture in this can live for 10 to 20 hours. This arrangement is also very good from the optical point of view.

The latest development is a chamber which is also bacteria-proof. The essential parts are a ground and polished glass dish with

a cover glass and a metal box with screw top. In this the culture can live for a long period of time. For this chamber a special objective corrected for an 0.5 mm. cover glass and a special condenser of 10 mm. focal length have been made by Carl Zeiss.

Fig. 7 represents an apparatus for taking motion pictures of human capillaries; these are the small blood vessels beneath the skin where the blood changes from arterial to venous blood. The problem was to determine cinematographically the speed of blood

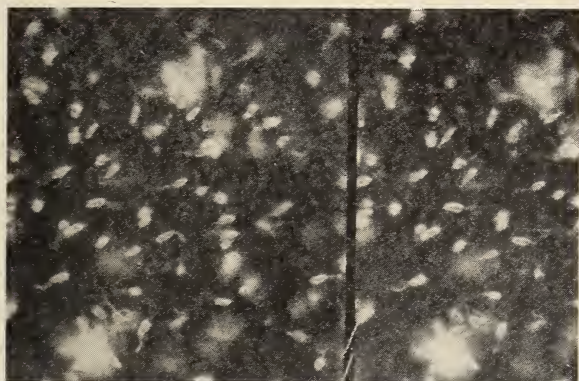


FIG. 9—Culture of Flagellates, *herpetomonas lygaeorum*.

flow and the movements of the capillaries. A special apparatus had to be designed. The apparatus is now in use at the Rockefeller Hospital for the study of heart diseases in combination with the cardiograph. The skin, mostly at the base of the finger nail, is made optically smooth by a drop of cedar wood oil, which permits better penetration of light. The light comes from a high intensity arc lamp (Fig. 8 from right to left), goes through condenser (1), cooling filter, condenser (2), to a 45 degree mirror (in this case the prism of a vertical illuminator), which covers only one-half of the objective. The other half is used in forming the image on the film. Polarized light (polarizer outside and analyzer in tube) is used in order to kill all secondary light (because it swings in one direction only), which otherwise would fog the image and make sharp and measurable films impossible.

In research work, the films not only have to be projected over and over again, but they also have to be studied frame by frame. This is made possible by a vertical projecting apparatus, which is

worked by hand. Thus the picture is thrown on a horizontal drawing board, and charts and drawings can be easily made from films.

The technic of taking micro-cinema films has been described sufficiently well in earlier papers by Stone and Tuttle.^{1,2} It requires actual practice however, to perform a number of manipulations at almost the same time. The beginner will use a great deal of film before he obtains good results; this depends, of course, more or less upon the ability of the operator.

It is hoped that there will soon be a complete micro-cinema apparatus on the market which will answer the requirements of those doing exacting work, for it will certainly be an aid to many branches of science.

Micro-cinema has opened up an immense field in medical and biological research and in all natural sciences. Instead of seeing in the microscope only the apparently motionless images of the specimens as we look at the illustrations of a book, we are now able to observe upon the screen how these small cells live and behave. It is possible, for instance, to study the action of malignant cells, such as tumor and cancer, on normal cells, and also the action of chemicals on cells. The importance of this is obvious as a possible aid, for instance, in the discovery of the origin of cancer and its cure.

A motion picture of the various subjects mentioned, especially of living cells, was projected at the meeting.

References

¹ "Motion Photomicrography" by G. E. Stone, Trans. S. M. P. E., Vol. X, 28, 1926, p. 196.

² "Motion Photomicrography with the Cine Kodak" Trans. S. M. P. E. Vol. XI, 30, 1927, p. 213.

DISCUSSION

MR. KELLOGG: I was so much impressed with the value of the films for educational purposes that I ask whether prints of them are available. I can speak for one crowd in Schenectady that would be fascinated by them.

DR. ROSENBERGER: We have only two prints of all our films, but I hope that very soon we shall have more available. The best thing to do is to write to the Rockefeller Institute.

“NARROW-CASTING”

JOHN B. TAYLOR*

WHILE there is much truth in the old saying “There is nothing new under the sun,” it often happens that an idea or a device is tried and discarded or remains dormant for a number of years. After a time conditions change, new needs arise, difficulties and limitations disappear in the progress of events. Then the old idea is brought forth again in new clothes to be acclaimed by those to whom it appears new and strange, and to be belittled by some who have read that so-and-so did about the same thing years before.

The demonstration of “Narrow-casting” which has been arranged for your edification is old in the broad sense but new (since many have not seen it), and new also in some details and in the employment of devices not available a half century ago when Bell and Tainter were experimenting with their photophone.

Bell and Tainter sent articulate speech a distance of several hundred yards over a beam of light. A powerful source of light was required—sunlight or electric arc. The diaphragm employed was of a size and tension to be deflected considerably under the fairly powerful tones of closely directed voice. Motion of the diaphragm either changed the direction of a reflected beam of light or moved some form of shutter to change the intensity of the beam. Their receiver or arrangement for translating from light back to sound was a large reflector with selenium cell at the focus and a battery connected in circuit with the selenium cell and telephone to be held to the ear. With this old apparatus, quality of speech or tone from musical instruments would probably not compare favorably with present day phonographs and radio loudspeakers.

In constructing a photophone at the present day for carrying speech or music, we have available several electrical devices with improvements unknown to Bell and Tainter at the time of their early experiments. Perhaps the most important of these are “radio-trons” (or vacuum tube amplifiers), photo-electric cell, oscillograph (or high frequency galvanometer), and gas-filled tungsten filament

* General Electric Co., Schenectady, N. Y.

incandescent lamps. Utilization of these modern amplifying devices in a photophone permits the feeble energy in a small beam of light to be increased sufficiently to give any desired amount of power for actuating a loud speaker. Similar amplifiers may be utilized at the transmitting end to enable sound-collecting devices to move mirrors or actuate other arrangements for controlling the light beam. The photo-electric cell responds faithfully to extremely rapid changes of light and consequently does not introduce distortion in the quality of music or give unnaturalness to the spoken voice.

While the tungsten incandescent lamp does not have the brilliancy of the electric arc, the greater simplicity, steadiness and ability to operate on a few cells of battery adds greatly to convenience, simplicity, and portability which are highly desirable in some applications of the photophone principle.

The demonstration of music in a beam or pencil of directed light has been called "Narrow-casting" in order to invite comparison and contrast with the parallel art of broadcasting.

For the demonstration the optical system of the transmitting station contained an oscillograph mirror which was caused to vibrate by means of a pick-up riding on a phonograph record. The vibration of this mirror changed the direction of a constant intensity beam of light in such a way that it was either allowed to pass or was partially intercepted by an opaque grating diaphragm. The beam of light between the transmitting and receiving station was thus caused to vary in intensity, the rate of this variation being dependent upon the vibration frequency of the sound record.

In the receiving station this intensity fluctuation was converted into electrical fluctuation through the medium of a photo-electric cell. This varying current was amplified by the usual radio amplification methods, and the sound was broadcast by means of a loud speaker.

An interesting point noticed was the 60 cycle hum of the room lights when the receiving lens was turned toward them. Although the ordinary AC light appears of constant intensity, it is really flickering.

The amount of light admitted to the receiving apparatus could be varied by inserting an opaque object anywhere along the light beam. As this amount was varied, the volume of the sound was changed.

REPORT OF PAPERS COMMITTEE

IN preparing the fall program your Committee has again endeavored to include as wide a variety of papers as possible, covering the branches of production and exhibition. Every effort was made to cover the subjects of sound recording, the electrical transmission of motion pictures, stereoscopic motion pictures, and motion pictures in color, which subjects are of primary importance at the present time. Your Chairman was successful in securing two papers dealing with the recording of sound; although considerable research is undoubtedly in progress on the other subjects, none of the persons approached was in a position to publish the results of his researches.

In this connection almost without exception, it was necessary to personally approach authors for papers and in many cases to suggest the subject and briefly outline the paper.

In view of the past interest shown in sessions devoted to symposiums on particular subjects, a symposium on projection has been arranged for Wednesday morning.

An innovation on the present program is the inclusion of a session devoted to the announcements of new apparatus by manufacturers and also the provision of free space for the exhibition of this apparatus. Although purely an experiment, your Committee is strongly convinced that the success of this part of our program is assured. Certain rules have been laid down regarding manufacturers' announcements as follows:

1. The apparatus described must be essentially new; that is, it must have been developed within the past twelve months.
2. A maximum time limit of ten minutes will be allotted to each manufacturer making an announcement.
3. The announcement should be read from a manuscript of not more than one thousand words, which must be in condition for printing in the Transactions.
4. The manuscript may be accompanied by not more than six illustrations. The actual apparatus or product may be exhibited during the talk but the ten minute limit for description is not to be exceeded.
5. Apparatus may be displayed in or near the room used for the technical papers sessions but no demonstrations will be allowed during the technical papers sessions other than at the session set aside for the purpose.

With regard to manuscripts submitted, your Chairman has insisted that in order to secure a position on the program proper the paper must not savor of advertising. In the past it has not been possible to adhere strictly to this rule, but the inclusion of the manufacturers' session makes it possible now to separate papers of an advertising nature from those which deal with pure research or which are of an educational nature. Also, many manufacturers have previously hesitated to submit papers describing their apparatus in view of the stigma usually attached to such papers when placed on the program of a scientific society.

Another innovation is the extra half-day session on Thursday afternoon and the reservation of many of the more important papers until Thursday. This has been done deliberately with a view to encouraging the members to stay throughout the entire convention. The number of papers allotted to each session has been strictly limited so as to permit ample time for discussion.

Popular abstracts of 90% of the papers have been handed over to the Chairman of the Publicity Committee.

J. I. CRABTREE, *Chairman*

C. E. EGELER

J. A. BALL

L. A. JONES

REPORT OF PUBLICATIONS COMMITTEE

Considering the comparatively brief period that has elapsed since the last report was submitted, little has transpired that calls for another. No. 29, Vol. XI., of the Transactions appeared ten weeks after the Spring meeting closed, though publication was delayed two weeks by special request. Under the existing, somewhat cumbersome method of handling the discussions, it would seem that about eight weeks is the shortest time in which the Transactions can be issued. Whether it is worth while to attempt to curtail this still more is an open question. But it may be of interest to draw attention to the fact that another society has published its journal, running to over 420 pages, three weeks after the close of the meeting of which it was the report.

E. J. WALL, *Chairman*

J. I. CRABTREE

K. C. D. HICKMAN

REPORT OF MEMBERSHIP COMMITTEE

The list of twenty-three new members for the first half of this year has been increased to forty-three during the past six months with a loss of only three units. The net increase of forty is a highly satisfactory mark of progress and an indication of the growing respect in which the Society is held.

While the growth is flattering to the Society, it is hardly so to your membership Committee. Out of the forty-three new members, more than twenty have been secured by your secretary, Mr. Porter, in the ordinary way of business; that is to say, by his own special magic. Fifteen have come from personal recommendations, which leaves only eight recruited by your Committee Chairman.

Four hundred and fifty letters typed individually from twenty or more persuasive form letters and more than three hundred "Aims and Accomplishments" booklets have been sent out. The resulting memberships amount to about two per cent. All the cameramen in Hollywood and most of the larger theater proprietors and projectionists in the country have been circularized. Three months ago, being anxious lest the letters were in the wrong vein, the Chairman sent specimens to Mr. Porter for his approval. He was pleased to say they were satisfactory.

The moral seemingly would be that a man is either a potential motion picture engineer or he is *not*, and if he is not, all the circularizing in the world will not make him one. If he *is*, the chances are that he will be known personally to some member of the Society; and it is that member's duty to see that he joins our ranks. This leads to the point made at the last convention: the true Membership Committee must always be the Society itself. Each individual should be responsible for recruits in his own neighborhood. All that the Committee Chairman can do is to furnish clerical aid and to co-ordinate efforts.

In the past year four important things have happened. We have lost by death two members of prominence, Carl Akeley and Raymond Peck, the one a famous explorer and sculptor, the other perhaps the most friendly influence within the Society.

The other matters, important from a membership point of view, are brought to light in two letters to your Committee, one from Prof. E. J. Wall, the other from Mr. Porter. Prof. Wall points out that since the Transactions can be bought for a fraction of the cost of membership, and since invitations to conventions are extended to all and sundry, irrespective of their belonging to the Society, what

incentive is there to join? Then comes Mr. Porter's lament that whereas the Society grows steadily, the number of Active members decreases, leaving the ranks more than half filled with Associates.

These two cries are really concerned with the same problem: the problem of the individuals attitude toward the Society. If the individual is going to ask for immediate rewards, he can get nearly all of them without joining. It is the long term benefits that membership assures. What has the American Navy to show for you this year; very little. It has welcomed home a great aviator and increased your income tax certainly, but it has fought you no battles and brought you no glory. Yet you are proud and glad to have it there because you know that in time of stress it is the bulwark between you and destruction. What has the Society done for you personally within the last year? It has dined a "captain of industry," gone quietly about its business, and incidentally taxed your income, but it, too, has fought you no battles, brought you no glory. But in the past it has done magnificent work on Standards and Nomenclature, and when the future call comes, you know it is going to do magnificent work again.

If a message or a slogan is wanted for the coming year, it is emphatically that Active membership is the normal duty of motion picture men.

K. C. D. HICKMAN, *Chairman*

CARL L. GREGORY

F. H. RICHARDSON

JOHN H. THEISS

W. C. VINTEN

OPEN FORUM

MR. CUFFE: On the Coast we don't hear much from different manufacturers who are members of this Society. If we could get a little more information about new articles as they are issued, it would help very much. After we do get it, we find that it is not the latest thing, whereas, if we had some idea that something new was being developed, we might hold off for a while.

MR. CRABTREE: I should like Mr. Cuffe to say something about the desirability of pushing ahead with the formation of an active section on the Coast.

I suggest also that each one of you, if you have any ideas regarding possible authors for papers or have a subject in mind which you think should be dealt with but don't know an author, mention

them to the Chairman of the Papers Committee; possibly he can find an author. Most members consider these meetings as something which happens twice a year, and they are willing to let a certain few do all the work. It means writing almost a thousand letters to get up a program of this nature. The acceptances are about two per cent of the number of men approached.

MR. CUFFE: I think a Coast section, if we could get enough members out there, would be a great thing. Of course, when there are meetings here in the East, I know every member of the Society on the Coast would come if he could. It is a long distance, and production is so heavy at the time of the meetings it is difficult to get away.

Mr. Ball had something to do with the Coast Section. We had one meeting and had a few papers, but there was no person behind the wheel to push it.

MR. CRABTREE: We want suggestions as to how to push it.

MR. CUFFE: Well, that is difficult for me to answer because I am just as busy as the rest of them out there. I should like to see one of the meetings out there in order to get under the skin of the producers and then you would have no difficulty in forming a Coast section.

MR. BEGGS: Are we doing anything of interest to the producers?

MR. CUFFE: Yes, but they want to see things before their eyes. I think if a meeting were held out there and we had the Coast workers at an open meeting and let them know what we are doing, that would give the necessary "push."

MR. CRABTREE: We are of the opinion that the present time is more opportune than ever for forming a Coast section because the producers are beginning to realize the importance of the technician and that he can put money into their pockets. The Society, as I see it, will have to be run by representatives of some of the large producers. No individual out there can afford the time at his own expense to promote the interests of the Society.

MR. CUFFE: I think that speaking for our company, the DeMille organization, our general manager and assistant general manager are behind this organization. DeMille is reaching for something we cannot always get on the Coast—the knowledge which this Society is supplying. Of course, there is a great amount of jealousy in this business on the Coast. This is due to the fact that the majority are not technically educated. They think: "We have something here we musn't tell anybody about because somebody else will get it; and we can't sell our picture because somebody else might get hold of it."

MR. MCGUIRE: The industry must know more about what we are accomplishing and the big producing and theater owning companies must take a greater interest in the Society before a successful meeting can be held on the Coast. If a demand for such a meeting comes urgently enough from the right people, the firms who have a membership in this Society will be less likely to hesitate about sending a representative on such a long and expensive trip. In the meantime, all publicity about the Society will be of value in helping our organization and increasing the chances of holding a meeting in Hollywood. It may appear that I am exaggerating the importance of publicity, but how can we expect the industry to take any interest in us unless they know what we are doing and how much we are contributing to the advancement of motion pictures.

MR. COFFMAN: In regard to the matter of increasing membership, particularly that on the West Coast, I suggest that it might be helpful for the organization to employ a field secretary competent to maintain contact with all desirable potential members. The Treasurer's report indicates that a permanent field secretary is out of the question, but some of the large corporations well represented in the Society might be persuaded to give one of their able men leave of absence to undertake something of this sort. In this way the Society might pay the salary and expenses of a good field secretary for, say, three months.

PRESIDENT COOK: That is a thought. Just to clarify the situation about the Coast meeting, I should like to have every one present who is sure that he could go to the Coast, if it should be selected as a meeting place for the next convention, hold up his hand.

(Seven hands Counted.)

DR. MEES: I don't think that gives the information. I don't think our men would care to say they would be sure of going, but probably we should have representation there.

PRESIDENT COOK: Probably a more practical method for arriving at such a decision would be a ballot sent to the entire membership.

DR. MEES: I should like to come back to the subject of making our Standards and Nomenclature work more aggressive. I think that conditions there at present are different from what existed in the past. I do not think Dr. Gage's reply is sufficient that I should send drawings to be ratified by the Society. I can send specific suggestions about amateur motion picture projectors, but I think the Society should be aggressively on the lookout giving a lead on recommended

practice to the trade. I still feel that the processes are too slow. I may be wrong on this—I know you have more experience on this than I have—but I do think that quick action in forming a preliminary recommendation which will prevent people going astray will serve its purpose. I think that writing a letter to a lot of manufacturers and asking them to agree is perfectly futile. I think that if the Society writes to each one to find out what is being done and then writes them that the average of all the results is so-and-so, you will get somewhere, but the Society must take the lead. It depends on how much the manufacturers weigh it seriously. As soon as the Society sees something arising in the industry, it should write to the people and suggest a course of direction in the right way.

PRESIDENT COOK: I am glad that Dr. Mees brought that matter up again in the proper place, because just now we are confronted with a little different situation than has occurred in the past ten years, and that is the sudden and acute interest in talking movies. In the past most ideas have crystallized gradually into accepted practice which we have adopted as standard, but here we have a new field, and the various concerns are showing their own mutual interest by making trade relations with each other which involve all three of the patent situations, and this is a most hopeful sign, because if these people can get together on the patent situation, it should be simple to convince them of the desirability of getting together on standards. We have evidently an acute situation in this particular branch of the industry.

I am going to assume the prerogative of appointing as many additional members to the Standards Committee as I can conceivably imagine will be of assistance in its functioning, with due approval, of course, of its Chairman, but Dr. Mees has certainly awakened us to the importance of this new branch.

MR. BEGGS: I think the way to handle this will be to appoint sub-committees, as we do in other societies. I feel sure there should be a sub-committee on the lighting of studios covering the whole field of sources, applications, and recommended practice.

PRESIDENT COOK: If you were here yesterday morning, you may recall that in my opening remarks I mentioned that we formerly had twenty-five committees, and a Studio Lighting Committee was one of them, and the activities of the Committee were not very great, but we might accomplish more under present conditions, and the Board will be glad to entertain your suggestion.

SYMPOSIUM ON NEW MOTION PICTURE APPARATUS

PRESIDENT COOK: This morning's symposium on equipment is somewhat of an innovation. It has been under contemplation by the Society for some time, and this is the first convention at which it has been in operation. Upon the success of this feature and its acceptability to the Society will depend whether we continue something of the same sort. I think from the interest shown this morning, this particular occasion has been appreciated and enjoyed by the Society.

It must be distinctly borne in mind that the presentation of any equipment of a proprietary nature at these meetings does not involve the Society's approval or recommendation or even opinion upon such equipment. The Society states in its "Transactions" that it is not responsible for the views of the contributors and never endorses any equipment, process, or description. I am mentioning this particularly because it has been brought to the attention of the Executive that certain approval of a publication by the Society has been claimed or inferred, and I wish to take this occasion to distinctly and emphatically state that no official approval is ever accorded by the Society to anything of the sort. The Society accepts written contributions to the industry and gives them publicity, but does not endorse them. Any such endorsement is entirely erroneous and without the Society's sanction or approval.

REFLECTOR ARC DISSOLVING STEREOPTICAN

J. H. KURLANDER*

In anticipation of the pronounced trend toward theater projection apparatus employing moderate currents a dissolving stereoptican lantern has been constructed on the reflector arc principle which uses but a single source of light for supplying both optical systems. The idea of supplying multiple optical systems with light from one source is by no means new, but the particular modification of the principle as used in this device presents new angles which should prove of interest.

* Brenkert Light Projection Co., Detroit Mich.

As illustrated by Fig. 1., a parabolic mirror, 11 inches in diameter and of 4 inches focal length, is used for the primary interception of light from an electric arc formed between carbon electrodes disposed in the usual horizontal manner.

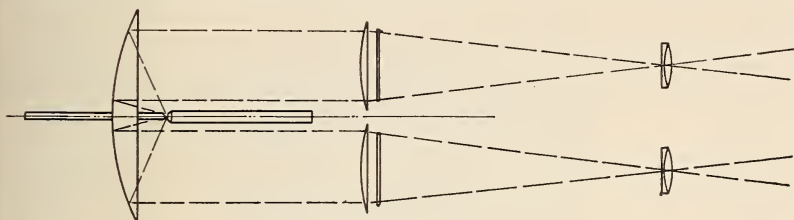


FIG. 1.

The position of the arc crater relative to the mirror is such that a slightly convergent beam issues from the latter to be intercepted by the condenser lenses and projected, as two separate beams of smaller diameter through the slides and into the projection lenses.

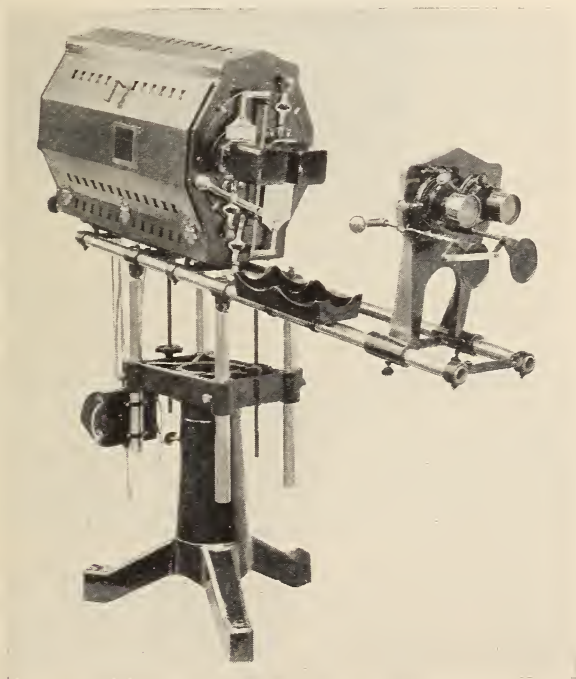


FIG. 2. The Dissolving Arc Stereoptican.

The object of converging the primary beam is to make the axes of the two secondary systems meet at the central point of the screen in order to effect the close matching of images necessary to successive slide projection. The mechanical

construction necessary to incorporate these various elements in the single machine is shown by Fig. 2.

A departure from the construction commonly employed in stereopticon lanterns is found in the positioning of the two optical systems side by side rather than one above the other. There is little choice in this respect because the vertical heat stream from the arc seriously affects the steadiness of the screen illumination when the path of the projected light is through the convection currents so established.

This placement of the slide carriers on the same level is really a decided advantage, since the slides are more accessible, there being no obstructions to interfere with their rapid exchange in the carriers.

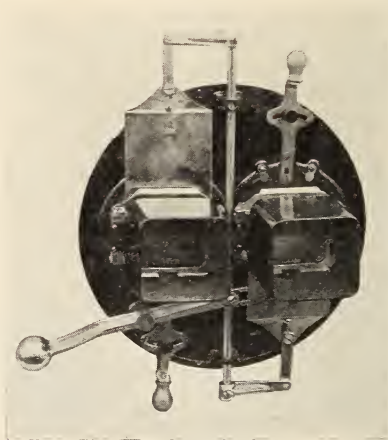


FIG. 3. The Front Plate.

The front plate of the lamphouse is constructed in such a manner that all principal adjustments required to match accurately both screen images are performed at this location rather than at the projection lenses. All working parts on the front plate, including the slide carriers and the curtain change-over shutters form a complete assembly which is rotatably mounted on the front plate (See Fig. 3). Rotation of this assembly permits the slide carrier openings to be adjusted for height.

Each slide carrier assembly in turn is rotatably mounted on the main assembly base, which allows the separate carriers to be corrected for skew.

In general, the arc burner used in this machine is of the conventional type with certain modifications to adapt it to the work at hand. The carbon holders have a travel long enough to accommodate a full trim of 16 inches. An arc control for automatic feeding of the carbons forms a logical part of the equipment, so that this unit represents a distinct step in the direction of easing the burden of the projectionist who gradually is being forced to assume a multitude of duties in the projection room.

It is interesting to note that the size of port opening required for this projector is considerably smaller than hitherto used. In fact, one measuring 8 inches x 10 inches is more than sufficient as may be seen from an inspection of Fig. 4.

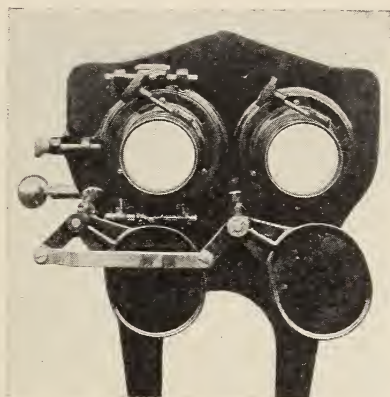


FIG. 4. Shutters and Mounts for Objectives.

Ample leeway has been allowed for in the matter of matching the screen images so that the projection lenses which can be used range from 10 inches focal length up to 36 inches.

DUPLEX OPTICAL PRINTERS

A. B. HITCHINS*

The Duplex optical and reduction printer is the result of an insistent demand for improved and more flexible printing methods. Contact printers, it is true, have a very definite place and function in the laboratory and for certain classes of work, such as the production of large editions, calling only for straight printing, they cannot be excelled. In recent years two things mainly have been responsible for the development of the optical printer. The first is in the standard or professional field, where standard 35 mm. negative is reproduced or optically printed on positive of the same width; the second is in the semi-professional field where standard width negative is optically reduced and printed on narrow width positive, which may be 28 mm., 16 mm., or 9 mm., although for practical purposes 16 mm. may be considered the universal and approved sub-standard width. Another application of optical printers that is quite important is the possibility of enlarging sub-standard negative to standard 35 mm. width. Directly we enter the field of optical printing, we open up a practically unlimited range of printing possibilities; every phase of trick and effect photography can be readily accomplished, limited only by the ingenuity of the operator. An optical printer skillfully used is capable of producing more photographic effects than a motion picture camera. To cover properly the full range of this work, two distinct types of Duplex optical printers are made.

* Duplex Motion Picture Industries Inc., Long Island City, N.Y.

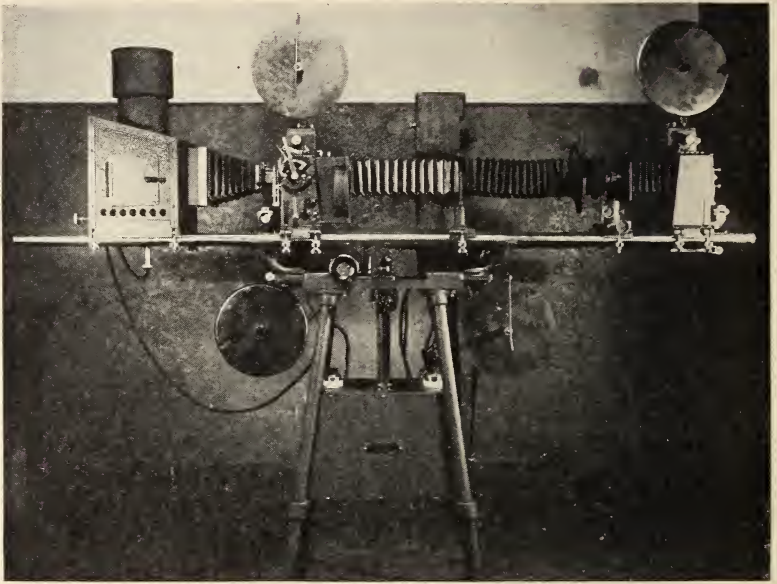


FIG. 1. Duplex Optical Printer Type A.

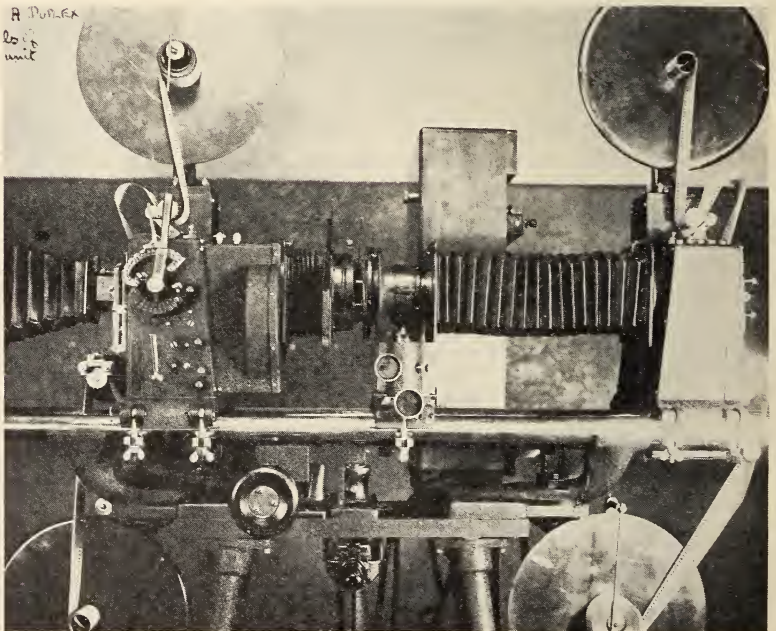


FIG. 2. Type A Optical Printer.

Type A is the standard model, producing 35 mm. prints from 35 mm. negatives. The printing heads and lens mount are movable upon an optical bed and permit an enlarging or reducing range of four times; that is to say, any chosen portion of the negative may be reduced or enlarged up to four times and placed

TYPE B DUPLEX

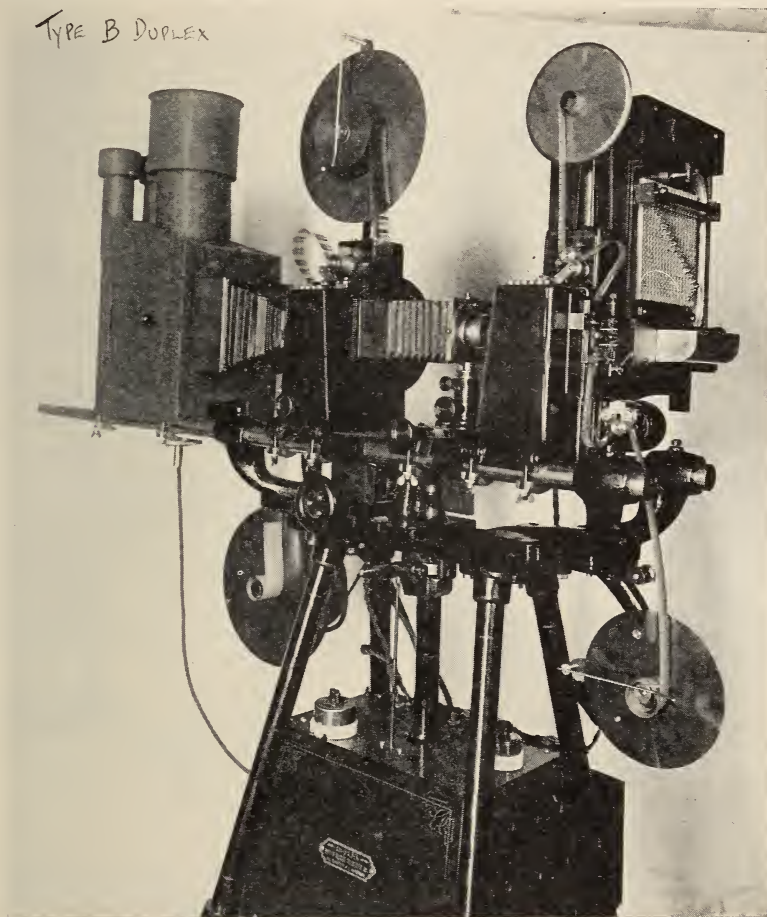


FIG. 3. Duplex Optical Printer Type B.

in any desired position in relation to the positive aperture, the lens mount having a three way movement actuated by suitable controls to accurately accomplish the placing of the image; the negative head is provided with a dissolving shutter that can be automatically closed down or opened up while running, and the length of fade-out or fade-in predetermined; also lap dissolves can be made. A complete trick unit is built into the lens mount consisting of a matte box, multiple exposure device, circular and rectangular vignette, curtain shutter, and blade cut-out. A

footage and frame counter is provided so that when multiple exposure or vision insert work is being done the exact amount of film that has been put through may be seen, and provision is made for winding back the film for the second printing. Both negative and positive heads are fitted with slots to accommodate standard masks, and the accuracy is such that a perfect join up is obtained without gapping or overlapping. Framing levers are provided on both heads.

It is obvious that with a machine of this type at one's command many expensive sets need never be built, for any desired detail or background can be printed by double exposure or with silhouette negatives. The printing light is controlled by Duplex automatics giving 18 changes of light and accommodating 21, 40, or 60 scenes as desired. The driving mechanism and the intermittent movements are of heavy construction calculated to stand up under the strain of continuous production, and the resulting prints have the characteristic quality that is recognized as being obtainable only with a step printer.

Type B Duplex optical printer is for the reduction of standard 35 mm. negatives to 16 mm. positives but can be furnished also for any other sub-standard width. There are a number of features built into this printer that make it a valuable piece of equipment,—for in addition to producing reduction prints optically it can be used for making 16 mm. prints by contact and also for enlarging 16 mm. to standard 35 mm. Both the negative head and the reduction head are connected to the automatic light change so as to operate both on the standard notch. The 16 mm. contact feature is particularly useful in a laboratory that has occasionally to print 16 mm. negatives and where there is not sufficient volume of this work to warrant the expense of a regular 16 mm. contact step printer. The light change on this model has a range of 18 lights and can be supplied to take care of 21, 40, or 60 scenes. The lens mount and both heads are movable on the optical bed, permitting considerable range in image size, and there is full control over the lens movement, laterally, vertically, and horizontally. Masks are supplied for controlling the negative aperture size so as to take care of shrunken negatives and framing levers are on both heads.

THE DWORSKY FILM-RENOVATING MACHINE, POLISHING MACHINE, AND FILM REWIND

A. S. DWORSKY*

At the July meeting of your body last year, Mr. Faulkner of Famous-Players Lasky Corporation told you of the unquestioned need which exists in the film industry for a simple and economical machine for cleaning motion picture film which during projection has become dirty and spotted with oil.

Since that time the Dworsky film cleaner has been markedly improved and its action made even more positive in producing clean, sparkling film such as will give keen pleasure to an audience instead of discomfort and disappointment, so that a better name for the machine than the film cleaner is "Film Renovator."

Briefly, the machine operates on the same simple principle, whereby windows are washed with water and squeegeed, only a non-inflammable fluid such as carbon tetrachloride is used instead.

* Dworsky Film Machine Corp., New York, N.Y.

The machine is entirely automatic in operation and does not require experienced operators or high-priced help. The film is first passed through troughs containing this liquid. The first trough is for the actual wash. The film then passes through a squeegee and over a piece of felt which removes practically all the dirt before entering the second tank. This keeps the rinsing liquid in the second

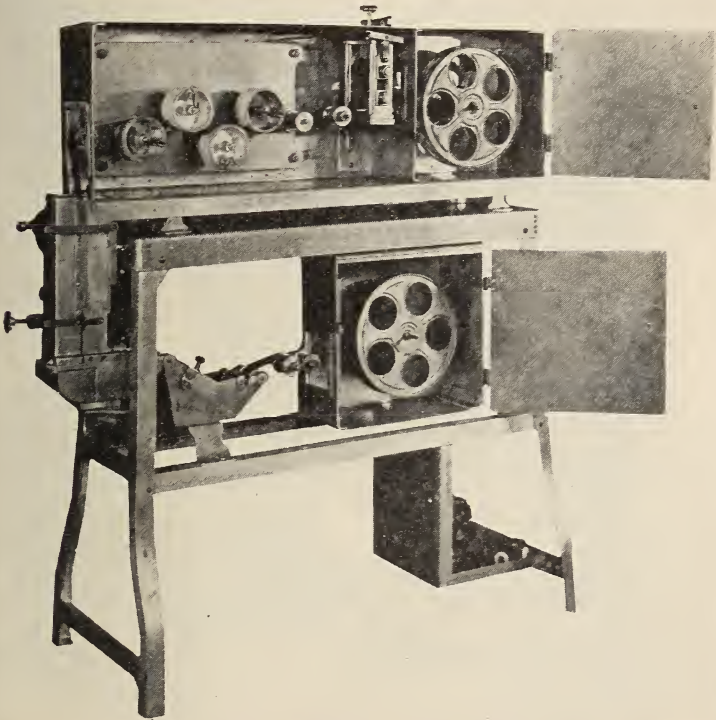


FIG. 1. Renovating Machine.

tank clean. After five reels of film have been cleaned, the dirty liquid in the first trough is drained off, and this trough is refilled from the second, or rinsing trough. The second trough is then filled with clean liquid. After leaving the second trough, the film passes over a squeegee with 3 wipers to remove the clean liquid, then through a series of roller buffers which wipe off the remaining fluid which has been carried along in the perforations. The cotton flannel on these buffers is 2 inches wide and 8 inches long and can be reversed and used on both sides. These strips are easily fastened in place on the same principle as a safety pin and are easily removed. Then the film passes between two rubber rollers, which pull the entire width of the film by friction. This method of traction prevents any damage to

the perforations which might result if a sprocket were used. The pressure of these rollers can be released quickly by an attachment on the top of the machine permitting manipulation of the film by hand during threading. The entire operation takes $4\frac{1}{2}$ minutes for 1000 feet of film. If the film breaks, an idler running on the film operates a lever which opens a switch, thus stopping the machine immediately. There is another switch which can be opened at any time by hand. The film is enclosed in magazines, and the entire machine is operated by one

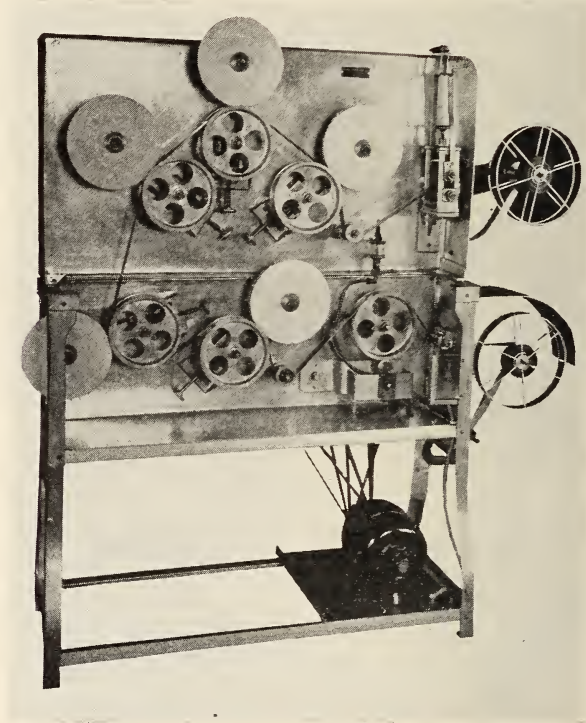


FIG. 2. The Buffing Machine.

$\frac{1}{4}$ H.P. motor. The machine is made of aluminum and measures 50 inches \times 60 inches \times 36 inches and weighs only 95 pounds complete.

We manufacture a number of different machines for the film industry, and together with the film renovator our buffing machine is probably the most valuable. This is also simple, efficient, economical and fool-proof. The buffing machine is intended for the processing of new film by waxing and polishing the emulsion side. First, the film passes over an idler, emulsion side down. This idler rotates another idler in a shallow tank of wax solution, thus passing a thin film of the solution from one idler to the other, and thence to the emulsion side of the film. All excess is scraped from the idler by a knife. The tank is refilled

automatically by a bottle placed above the tank. From this roller the film passes under a small idler and over a large idler, where a buff polishes the film base side, then over four idlers and four buffs which polish the emulsion side. These buffs are made of cotton flannel and rotate at high speed. The shafts run on ball bearings and can be adjusted to compensate for wear of the buffs, so that sufficient force is supplied to the film always. After passing the buffs, the film passes between two rubber rollers as in the renovator. These rubber rollers have the same ar-

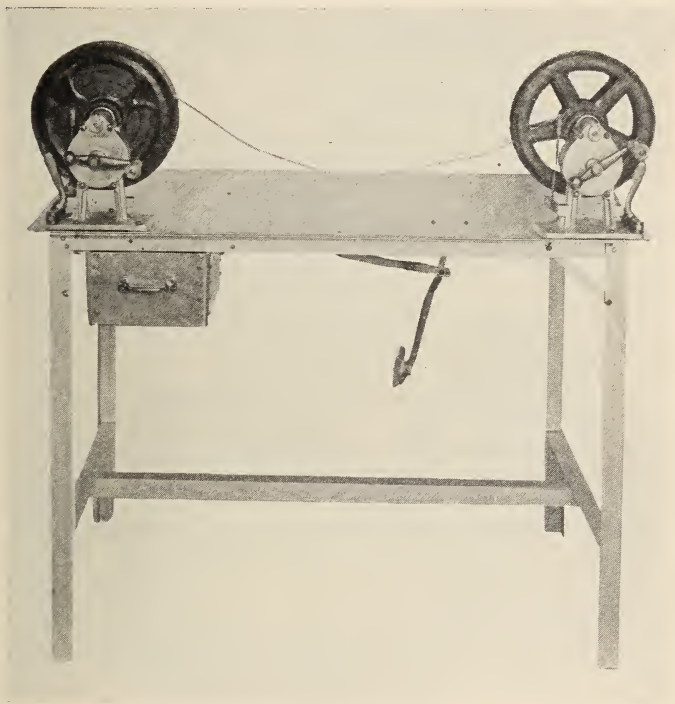


FIG. 3. The Braked Rewind.

angement as in the renovator for removing the pressure from the rollers to permit of hand manipulation. The entire machine is operated by one $\frac{1}{2}$ H.P. motor, is made of aluminum in natural color, measures 50 inches \times 16 inches \times 40 inches and weighs complete, only 125 pounds. The entire operation occupies approximately $4\frac{1}{2}$ minutes for 1000 feet of film and can be performed by low priced help.

Another Dworsky machine which will be of interest to you is the braked rewinder. This is a very simple yet highly useful adjunct to your equipment. It is an inspection rewind, equipped with two-wheel brakes similar to those on an automobile except that they are operated by a slight movement of the knee. Both reels stop at the same time and hold firmly in place without running over. Dragging and scratching of the film are thus eliminated. Inspectors can use the

free hand to detect a broken perforation while stopping the rewind, thus preventing a needless loss of time and enabling them to give more than a casual thought to their inspection. At the same time, any possibility of film dragging on the floor of the inspection room and thus picking up grit and dirt is eliminated.

THE MODEL B KODASCOPE*

The Model B Kodascope is the latest development of the Eastman Kodak Company in 16 mm. projection equipment. It has, we believe, all the characteristics of the best 16 mm. projector now on the market and in addition it has

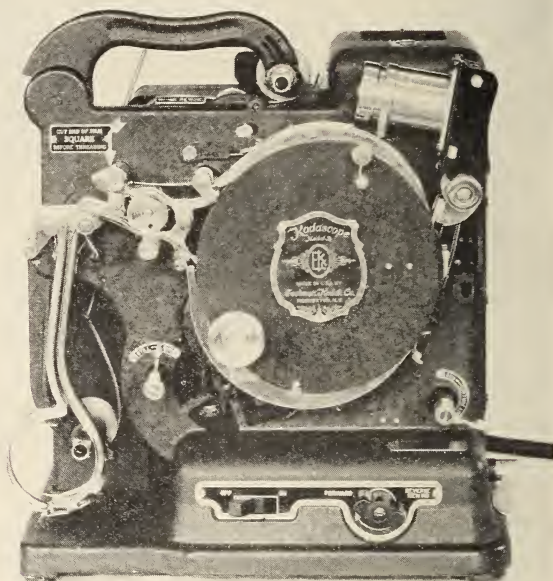


FIG. 1. The Kodascope Model B.

several devices and attachments entirely new to the field. It is evident from the appearance in Fig. 1 that everything has been done to make the projector as compact as is feasible. Its shape ensures maximum stability both during projection and when idle.

Light is furnished by a 50-volt 200-watt T-10 Mazda lamp in prefocused base, the optical system being such that maximum screen brightness is obtained from this lamp, which is the best available for the purpose. Fig. 2 shows the lamphouse open.

The intermittent movement is a cam operated skipstroke double claw, pull-down being accomplished within 60°. This is shown in Fig. 3.

* Eastman Kodak Co., Rochester N.Y

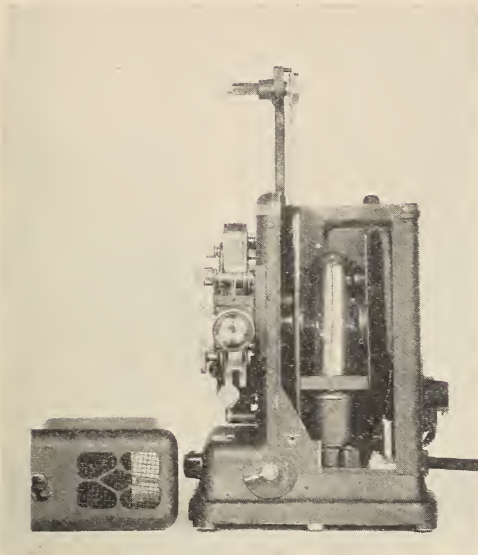


FIG. 2. The Lamphouse.

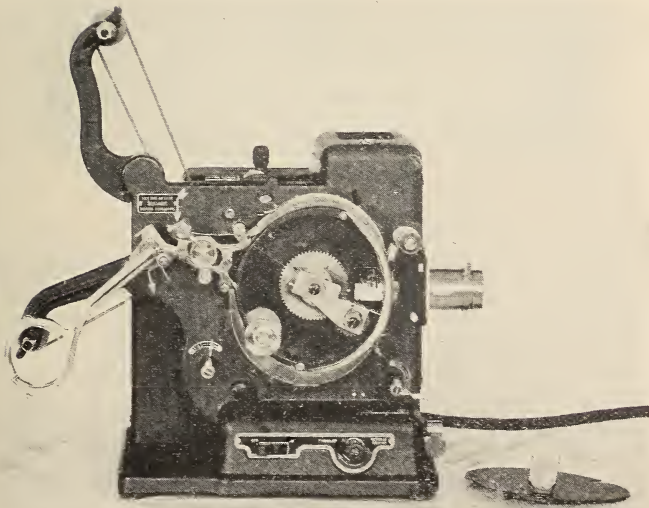


FIG. 3. The Intermittent Movement.

The self threading feature is the most novel device on the Model B Kodascope. A reel of film is placed on the upper spindle. The end of the film is inserted in a slot in the upper sprocket clamp and the current turned on, as shown in Fig. 4. The perforations automatically engage the sprocket teeth which send the film into a closed channel, or upper loop former, leading to the pull-down. The pull-down leads the film into another closed channel or lower loop former which leads back to the sprocket. The sprocket sends the film to the take-up reel through another channel which, when in threading position guides the film around the



FIG. 4. The Self-Threading Device.

take-up reel core. After the film has entered this channel, the current is turned off and, by means of a lever, the loop formers are moved away from contact with the film loops and the current is turned on again, the picture at once showing normally on the screen. When several convolutions of film are wound around the core of the take-up reel, the take-up channel springs apart automatically, the take-up functioning in the ordinary manner.

Reverse projection is effected by turning a switch to "reverse" position. Normal or reverse projection is accomplished instantaneously. Overrunning clutches in upper and lower reel shafts automatically take care of the reversal.

Single frames may be projected at full brilliancy, the film being protected by a special screen between the condenser and the lamp. This shutter is actuated by a lever conveniently placed directly behind the pull-down chamber. Single frames

may be shown during either normal or reverse projection. The film may be advanced or reversed, frame by frame, by means of a cranking knob.

A knurled knob on the end of the shaft on which the lens mount and aperture plate are mounted operates an eccentric which raises or lowers the frame. It is quick acting and positive and does not require raising or lowering the whole projector to compensate for the shift.

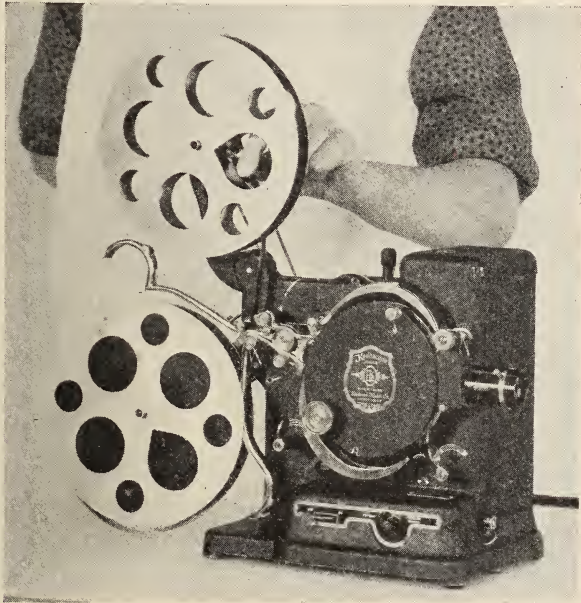


FIG. 5. Rewinding.

Lenses are quickly interchangeable. A flange on the rear of the lens mount slips in or out of flanges mounted on the lens bracket. The lens is held in the bracket by a snap spring.

When a reel of film is to be rewound the end of the film is brought up to the empty upper reel through a break in the threading channel as shown in Fig. 5. The direction switch is turned to "rewind" and the current turned on. Then, when a clutch is let in, the upper reel is rotated at high speed. Sufficient tension to insure tight rewinding is maintained on the lower reel and 400 feet can be rewound in approximately one and one half minutes.

Variable rheostats are furnished for controlling the lamp current and the motor speed. An ammeter shows the current flowing through the lamp (Fig. 6).

All bright parts are chromium plated instead of nickeled. This insures better appearance throughout the life of the projector.

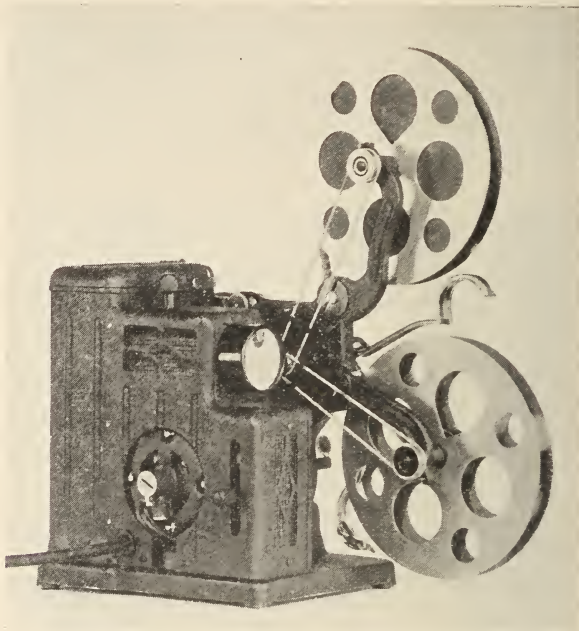


FIG. 6. Rear View of Kodascope.

DISCUSSION

MR. BAUER: Is the beam projected directly or indirectly through the film?

MR. GREEN: The light is indirect. It is turned through an angle of 90° by a silvered mirror located near the pull-down.

VOICE: What does the machine weigh?

MR. GREEN: Approximately thirteen and one-half pounds

RECENT DEVELOPMENTS IN THE PREFOCUSED BASES AND PREFOCUSING SOCKETS FOR PROJECTION LAMPS

R. S. BURNAP*

Synopsis:—This paper discusses improvements in the medium sized prefocused base and prefocusing socket for projection lamps and describes the development of a larger size base and socket to replace the present threaded mogul base. The new base will extend the application of prefocused bases to the higher wattage projection lamps.

At the 1925 meeting of the Society at Roscoe, a paper was presented by the author on a new prefocusing socket and prefocused base for projection lamps

*Edison Lamp Works of General Electric Company, Harrison New Jersey.

which had been developed by the lamp manufacturers to supply a need on the part of projection equipment manufacturers for greater accuracy in locating the lamp filament in projection equipment than obtainable with the medium screw base and socket.

Since it is practically impossible, at least in the present stage of the art, to manufacture projection lamps and to base them with medium screw bases, with the required accuracy for use in high grade projection equipment, projection equipment manufacturers have had to supply adjustable sockets in projection equipment where the maximum optical efficiency was desired. The threaded base adds a further difficulty—that the thread of the base and the socket does not permit of predetermining the plane of the filament with reference to the optical axis without setting the socket individually for each lamp.

Everyone interested in projection problems realizes the difficulties, even for an experienced person, of making lamp and socket adjustments, particularly when the lamp is hot. With the purpose of making lamps as readily interchange-

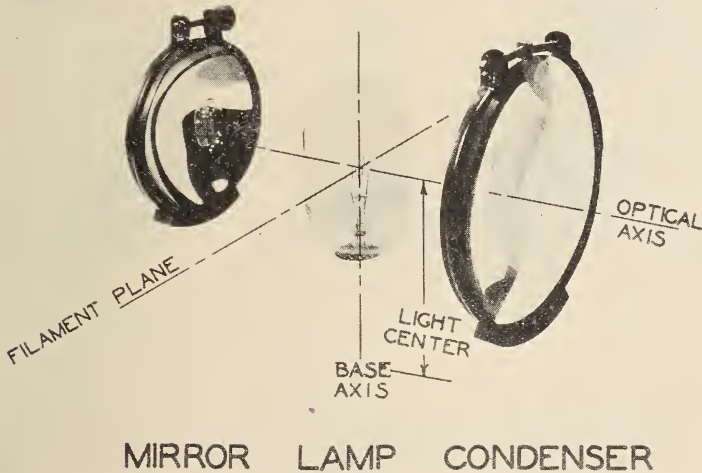


FIG. 1. A Usual Projection Set-up.

able as is now the case in the usual lighting fixture, the lamp manufacturers developed for projection lamps a prefocused base and prefocusing socket which automatically places the light source in the correct position provided that the socket, mirror, condensers, etc., are correctly adjusted in the factory for the lamp. The original designs of the prefocused base and prefocusing socket were made as simple as possible to accomplish the purpose, and were worked out with base and socket manufacturers to insure satisfactory manufacturing conditions. It was the belief of the lamp manufacturers that a satisfactory prefocusing socket and base would bring about standardization and simplification of apparatus, and

thus prevent confusion by having the minimum number of special lamps and bases for projection purposes.

At this point it is desirable to describe again the fundamental requirements for a satisfactory prefocused base and prefocusing socket: (Fig. 1 shows a usual optical arrangement.)

1. Accurate light center
2. Accurate axial alignment of filament and base
3. Positive location of filament plane
4. Definite positioning of filament anchors
5. Correctly aligned socket
6. Correctly aligned optical system

Reducing these requirements to the simplest formula means that the base must be adjustable at the time of assembly with the lamp and must provide positive bearing surfaces to align the filament on the socket axis and at the correct height above the socket. These requirements are covered by providing two shells for

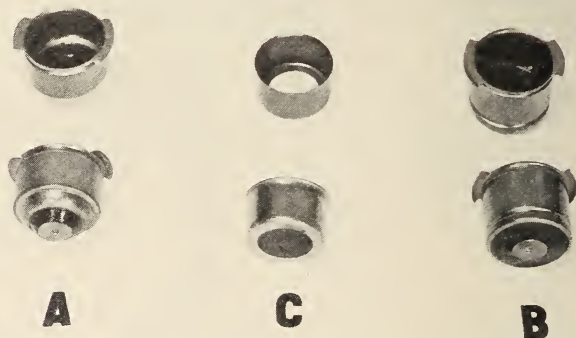


FIG. 2.

- A. Earlier Base Outer Shell.
B. New Base Outer Shell.
C. Inner Shell.

the lamp base. The inner shell is cemented to the lamp in the usual manner and is adjustable in the outer shell upward and downward, and with a rocking motion to correctly align the filament with reference to the axis of the outer shell. This operation is done in the lamp factory at the time of manufacture in accurate optical jigs. After the filament is correctly located with reference to the base, the inner and outer shells are soldered permanently together.

The cylinder of the outer shell when placed in the socket shell provides axial alignment. The location of the filament for light center is determined by flanges on the outer shell, which engage with ears in the socket. The position of the filament plane is determined by unequal sized base flanges, which can engage the socket in only one position. All lamps are based by the lamp manufacturers

so that the filament anchors are toward the observer when the lamp is viewed with the 60 degree or smaller flange on the left. The eyelet (bottom contact) on the outer shell and the flanges of the base provide current carrying terminals.

The assembly of the base and socket must be simple. For this base the operation requires only that the base cylinder be dropped into the socket shell and the base flanges passed through the openings in the socket ears. The lamp is then depressed against the retaining spring and turned 90 degrees to a fixed stop. When this is accomplished, the lamp is released and will be heard to click into position. The base flanges and the socket ears are held in positive contact by means of a plunger with a compressed spring, which presses against the bottom contact eyelet.

The base and socket described in the previous paper have enjoyed wide use. As might be expected, the prefocusing base and socket have been subjected to further investigation and improvement as a result of service in the field. The fundamental principles governing the design of these parts have been found to be sound, but changes, with the intent of making parts more reliable in the assembly, more rigid and better adapted to machine production, have modified the original appearance to some degree. All of the changes, however, which have taken place

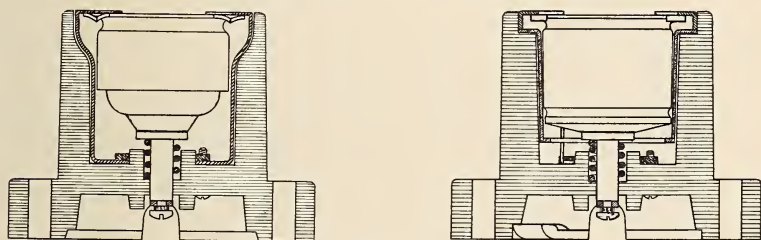


FIG. 3.

Earlier Base and Socket.

New Base and Socket.

have been made so that the sockets and bases of the new design are still interchangeable with those of the old design. Fig. 2 shows the old and new base designs, and Fig. 3 shows the old and new socket part design. The improvements have increased the inherent accuracy of the base and socket assembly. As will be noted in Fig. 3, the outer shell of the base has been lengthened so as to increase the bearing surface in the socket. The socket itself has been changed in design so as to give a longer bearing surface on the outer shell of the base. These two changes limit the back-lash of the base in the socket very decidedly as compared with the earlier design. Fig. 4 shows lamp based with new socket.

The early base design had the corners of the engaging flanges turned downward so as to insure a better meshing with the socket at assembly. The design of the new socket eliminates the possibility of incorrectly meshing the socket and base, so that this feature is no longer necessary. In order to reinforce the flange, a turn-down is now formed on the outer edge. This has the advantage also of stiffening the flanges against distortion for a faulty insertion of the base in the socket and prevents the faulty assembly of a flange above the socket ear. The

elimination of the turn down corners of the early design has resulted in an increased bearing surface between the base flanges and the socket ears for a better seating of the base in the socket.

It will be noted that the first socket shells were made of one piece of metal formed to shape. The new design consists of two parts firmly clamped together.

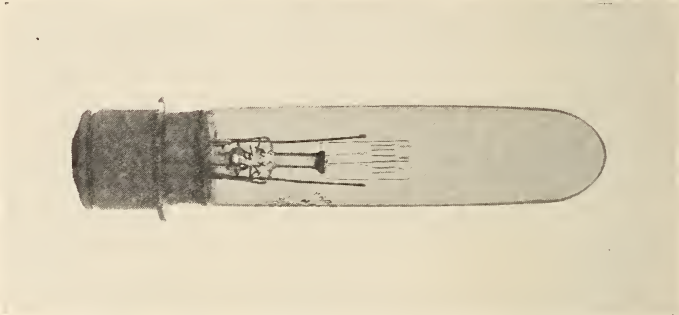


FIG. 4. Lamp with New Medium Prefocused Base.

This construction permits of making each part more accurately and of proportioning the metal thicknesses to the strains incurred.

Improvements, of course, have been made in the first experimental jiggling equipment as production has increased, and additional jigs for checking alignment have been provided in the factory for a final inspection.

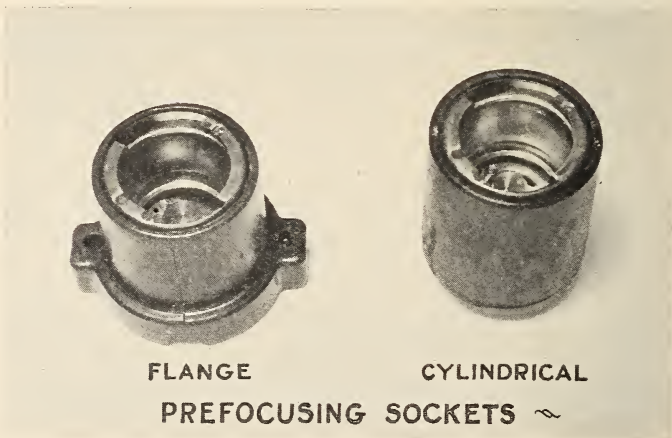


FIG. 5.

Two styles of socket have been developed for use with this base. (See Fig. 5.) One a flange type is designed to bolt directly to some fixed part of the projection equipment. This operation is done by the manufacturer at the time of assembly

of his equipment. The socket should be adjusted to the correct height and position and firmly fixed in place so that the user will not find it easy to move the socket out of adjustment. A similar socket has also been developed, consisting of a cylindrical insulated section in place of the flanged section, which may be set in a split ring and clamped in position. A reference line is indented in the socket to guide assembly. This socket has found considerable use for replacing the threaded base socket in projection equipment. The inner shell parts of both sockets are identical.

At the Roscoe meeting after the prefocusing socket and prefocused base had been described one of the members inquired about the prospects for a mogul prefocused base and prefocusing socket. Since the demand for a mogul



FIG. 6.

- A. Mogul Prefocused Base Outer Shell.
- B. Mogul Prefocused Base Inner Shell.

prefocused base and prefocusing socket is not as great as for a medium type and since the cost of these larger parts will necessarily be considerably higher, progress along this line has been rather slow. However, the lamp manufacturers now have this development actively under way. The mogul prefocused base is in principle and appearance very similar to that used for replacing the medium screw base, except for its larger size and more rugged construction. Fig. 6 shows the base parts. In order to take care of the high temperature at which these bases will operate, the parts will probably be welded together instead of soldered, as for the medium type. Fig. 7 shows a based lamp.

The model of the mogul prefocusing socket shown and described has been worked out as a preliminary design to utilize the mogul prefocused base to the

best advantage, but is not necessarily in the final commercial form. A description of this preliminary design of the mogul prefocusing socket, however, will show the trend of the development.

This design is similar to the cylindrical type of the smaller prefocusing socket. The parts, of course, are heavier, so that the base and the socket make a very substantial and rugged combination. The model is adapted for use either as a cylindrical type to be fastened in a clamp or as a flange type to be bolted to a bed-

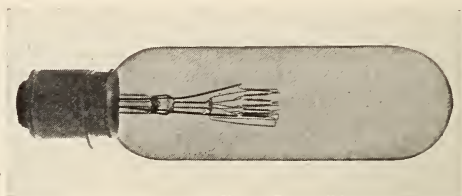


FIG. 7. Lamp with Mogul Prefocused Base.

plate on the projection machine. This dual feature is accomplished by means of a separable cap at the bottom of the socket which protects the lead-in wires and has screw holes for retaining bolts. Fig. 8 shows the external appearance and Fig. 9 is a cut-away section of this socket.

The mogul prefocused base has been designed with a $\frac{7}{8}$ inch diameter bottom eyelet. The large area for contact which this eyelet offers is taken advantage of in the socket design, so as to give the maximum area of reliable contact. This makes it possible to obtain large current carrying capacity without having to place the contact parts under excessive pressure. This large area of contact

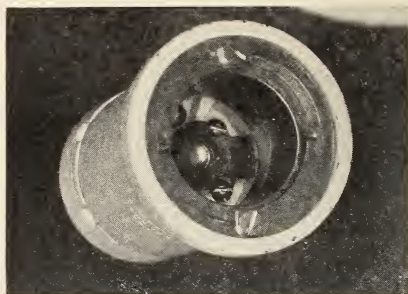


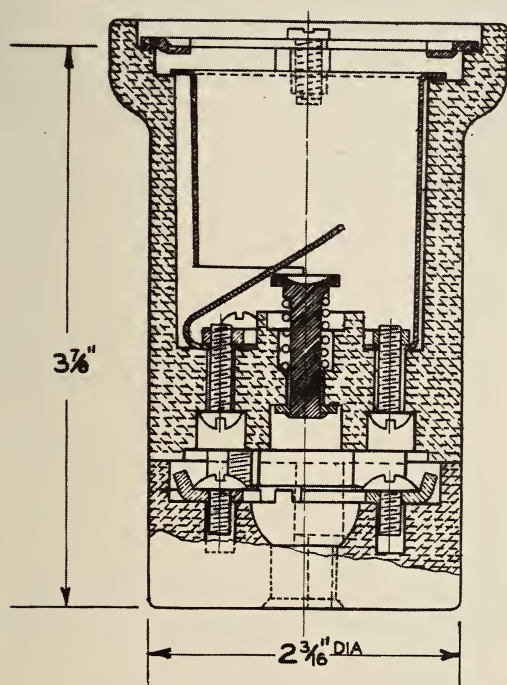
FIG. 8. Preliminary Model of Mogul Prefocusing Socket.

between the base and socket plunger has been insured in this design by using a multiple leafed bottom contact which presses against the outer section of the base eyelet. Current to the plunger and the contact points is carried through a heavy flexible strap so that no current is carried by the retaining spring, thus preventing overheating of this part.

To discuss among users and manufacturers of projection equipment the various fields for prefocused lamps is perhaps carrying coals to Newcastle.

Nevertheless, the author is going to risk that possibility in reviewing and suggesting applications.

A complete list of possible uses for prefocused base lamps would practically cover the entire field of projection equipment. Perhaps the field of largest interest to the members of the Society is that of the portable motion picture machine. The medium sized prefocused base has already found extensive application in



MOGUL PREFOCUSING SOCKET

FIG. 9. Sectional View of Preliminary Design of Mogul Prefocusing Socket.

this field. Prefocused bases have application in stereopticons, slide film projectors, theater effect machines, spotlights, floodlights, headlights, signal lamps, searchlights, light house lanterns, advertising projectors, etc.

Since the result of the use of prefocused bases and prefocusing sockets is to make the accurate placement of lamps in projecting equipment as simple as for ordinary lighting service, it follows that these bases and sockets will find wider

application. The conditions which make the use of prefocusing sockets and prefocused bases desirable are necessity for accurate control of projector beam, supervision of equipment by unskilled maintenance men, and saving in time and labor for skilled men.

The problem of lighting aviation landing fields and courses requires projecting equipment with the beams accurately focused and placed. The difficulties of meeting these conditions with unskilled maintenance men, particularly in outlying districts, would seem to point to the use of lamps equipped with prefocused bases. The fact that focusing by trial of a threaded base lamp necessitates knowledge of lighting requirements and skill, must be done at night, oftentimes in disagreeable weather, and at the tops of towers, making a focusing operation very undesirable. The use of the prefocused base and prefocusing socket requires only that a skilled man adjust the initial installation for the best results. After the projector is once properly located and clamped in position, the operation of replacing lamps is comparatively simple and may be done at any time.

The use of prefocused bases and prefocusing sockets in aviation field lighting has been given as an example of a possible case where this equipment should prove desirable. This example undoubtedly will suggest other uses where the fact that the required adjustments can be incorporated in the lamp assures high quality of light control under all conditions.

It may be of interest to note the types of lamps which are available with medium prefocused bases at the present time. In general all medium screw projection lamps can be furnished with the prefocused base. The following lamps have fairly wide application at the present time:

100 watt, 115	volt, T-8½	coiled coil filament
200 watt, 115	volt, T-10	coiled coil filament
200 watt, 50	volt, T-10	
250 watt, 115	volt, T-14	
300 watt, 28-32	volt, T-16	
500 watt, 115	volt, T-20	

The lamps which will prove most popular with the mogul prefocused base remain to be worked out, but the 1000 watt, 115 volt, T-20 lamp will probably find the largest application.

IMPROVED MOTOR GENERATORS*

The Hertner Electric Company announces a new line of motor generator sets for supplying direct current to the projection room. These motor generators will be "Type C. P. Transverters."

The distinct feature of these Transverters is the voltage regulation of the generators. The voltage of the usual commercial type of generator will decrease from 10% to 15% when operated with a fixed field regulator over a period of time sufficient for the windings to reach a constant temperature. This means that, in order to obtain satisfactory results with the projection equipment the projectionists must manipulate the field regulator as the generator warms up so as to maintain a constant bus voltage.

*Hertner Electric Co.

The type C. P. Transverters are designed to deliver within $2\frac{1}{2}\%$ of the rated voltage under all conditions of temperature and loads (within the rating of the generator). This feature makes it possible for the projectionist to operate the Transverter during the entire show without manipulating the field regulator. As an example the hot and cold voltage ampere performance curves of the type C. P. 300 ampere 100 volt Transverter show the small decrease in voltage of the generator as it heats up.

VOLT AMPERE PERFORMANCE
300 AMPERE 100VOLT
MULTIPLE ARC TransVERTER
SERIAL No. 7909

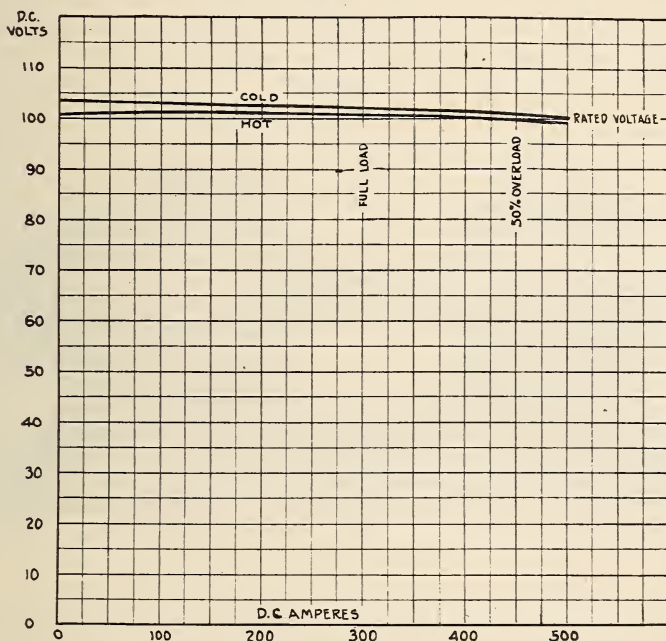


FIG. 1.

These Transverters are rated on a projection room duty basis. The Power Club rating for 40°C . machines is that no part of the machine shall have a temperature rise above the room temperature of more than 40°C . when operated continuously at full load except the commutator, which may have a rise of 50°C . When operated at 25% overload for two hours the temperature rise of the windings should not exceed 55°C . and the commutator 70°C . The projection room duty rating which we have adopted for type C. P. Transverters is the same as the Power Club rating for continuous duty but is on a basis of 50% overload for thirty minutes. This latter rating, we feel is very much more adapted to projection room conditions, as there will probably never be an occasion to operate at an overload for more than thirty minutes in any two hour period.

The type C. P. Transverters are built in the four oil bearing type consisting of a squirrel cage induction motor specially designed for motor generator service direct connected by means of a flexible coupling to the generator. The two units are mounted on a substantial cast iron base. The generator is particularly well ventilated, provision being made to draw air in through the commutator core and also through the rear end of the armature, and discharge it about the field coils. The entire generator is designed with the idea of keeping the voltage variation down to a minimum. This has made it desirable to build the generator as open as possible so as to permit maximum ventilation. The frames are relatively large as compared to the size of frame usually used with a given diameter armature. Sufficient room for the shunt field winding is secured in this way.

The most advanced methods are used in the construction of these machines. The machined parts are finished to a precision beyond usual practice. The shafts are of medium carbon steel and ground to a high finish. The rotating parts are balanced dynamically on a Gisholt Balancing machine, which produces results of the highest accuracy.

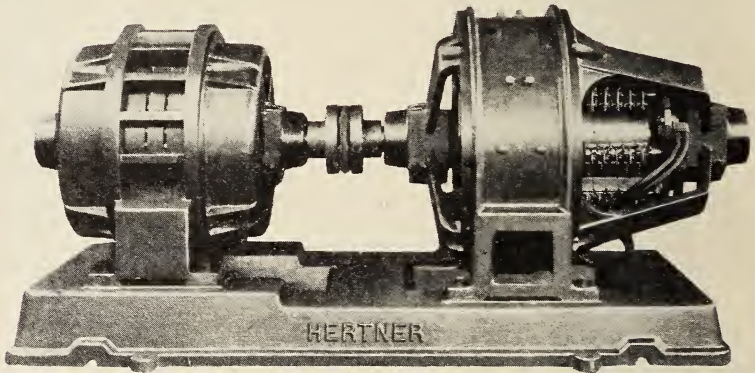


FIG. 2. Hertner Type C. P. Transverter.

The type C. P. Transverters have been designed to deliver 100 volts direct current. It seems to be the consensus of opinion that a D.C. bus voltage of 100 volts is desirable where high intensity lamps are used. However, they can be furnished to deliver 85 to 90 volts direct current if so ordered. The very close voltage regulation will only be obtained when operating at the rated voltage.

The type C. P. Transverter is now offered in continuous capacities of 150, 200, 250, 300, 400, 500 and 600 amperes at 100 volts.

DISCUSSION

MR. CRABTREE: What is the price of the outfit?

MR. DASH: It is a little higher than the ordinary machine but will approach that of a motor generator set of the same rating. I might mention that we have built one with 1200 r.p.m. instead of 1800, feeling that the exhibitors would pay

a little more for it. In the same length of time the armature doesn't travel so far and consequently doesn't wear out so fast.

DR. GAGE: Could they be built for 120 volts without too much additional expense?

MR. DASH: We are rather a small concern. You all know Mr. Hertner; he and I constitute practically all the engineering force and we have built them for 32, 39, 48, 100, and 125 volts, and one for 128 volts, so that the machines are practically tailored to the job without additional expense.

AN IMPORTANT IMPROVEMENT IN POWER'S PROJECTOR MECHANISM

HERBERT GRIFFIN*

This paper has to do with that very important part of a motion picture projector mechanism known as the film gate. For many years past this structure on all makes of motion picture projectors has been of very simple and elementary design and extremely light construction. It was realized that some method must be devised to hold the film in focus and under sufficient tension to keep it steady over the aperture and not a great deal of ingenuity was necessary to construct an assembly along cut and dried methods which would accomplish this result.

In this paper the new film gate on the Power's mechanism will be described. The old gate on the Power's projector was simply composed of a thin brass casting on the front side of which was mounted a fire shutter of very limited proportions and rather doubtful efficiency, and on the inside a tension shoe approximately 3 inches long having polished tracks one on either side of the aperture but each made in a solid piece. This shoe was held under tension by means of two short flat steel springs, no attempt being made to have the tension fixed, reliance being placed entirely on the judgment of the projectionist as to just what tension might be required to keep the projected picture steady. Practically no attention was given to heat dissipation, and the so-called cooling plate on the gate simply served as a slight protection for the tension springs which otherwise would have been subjected to the entire effect of the heat rays in the spot.

The advent during recent years of the extremely intense illuminants for the projection of motion pictures and the tremendous amount of heat generated by them brought about conditions which badly needed attention, and the problem has been satisfactorily solved with this newly designed film gate.

The greatest difficulty was to construct the new equipment so that it might be attached to any Power's projector and at the same time satisfactorily eliminate the objectionable features of the old construction. It is well known that the heat from the high intensity and reflector type of lamp has been doing considerable damage to the gate structures, tension springs, and the fronts of the mechanism themselves, and also innumerable complaints have been received with regard to in and out of focus effects on the screen which have been blamed on the film buckling but which in a great number of instances was really due to the heat removing the tension from unprotected tension springs and again from the method

*International Projector Corporation, New York City.

of construction of the tension shoes and the manner in which tension was applied to them. Fig. 1 shows the old type gate construction.

In the design of the new gate the following points had to be carefully considered:

1. An adequate and positively acting fire shutter must be provided.
2. There must be plenty of air space between the various elements of the gate to carry away the heat as rapidly as possible.
3. The front section nearest the light must be so designed as to rapidly dissipate heat.

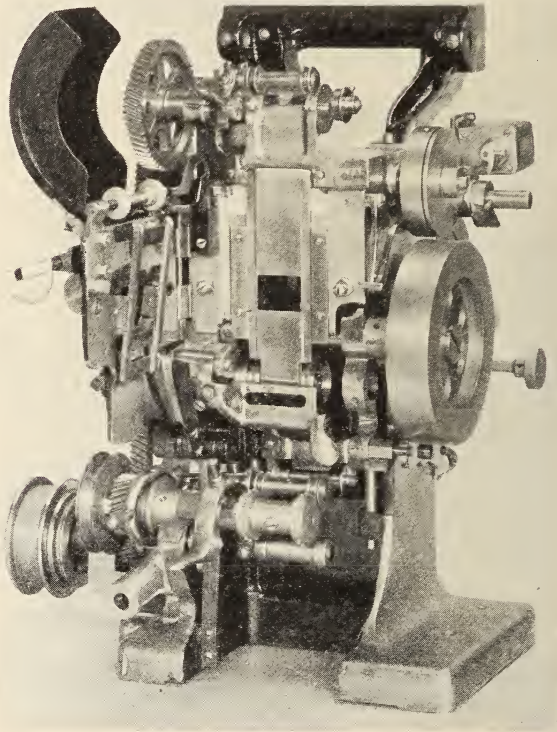


FIG. 1. Old Type Gate.

4. Such parts as are subjected to heat and which must be handled by the projectionist must be heat insulated.

5. The tension springs operating the tension shoes must be far removed from the source of heat and carefully protected so that the temper will not be drawn from them and the tension shoes themselves must be so constructed and arranged that the minimum amount of tension will be required in order to hold the picture steady over the aperture.

Fig. 2 shows the new Power's gate and lower fire shield closed.

While all of these features have been realized in this new equipment, it has taken a great deal of time to develop and place the apparatus on the market. Many metal compositions were tried in order to discover what would dissipate the most heat and at the same time maintain its configuration rigidly under considerable change in temperature. Bronze, aluminum, German silver were all considered, but in the final analysis it was found that cast iron served the purpose entirely satisfactorily and it is from this material that the front and back plates are made. Both of these plates are finned and are similar in appearance to a waffle iron, and this design has been found entirely satisfactory.

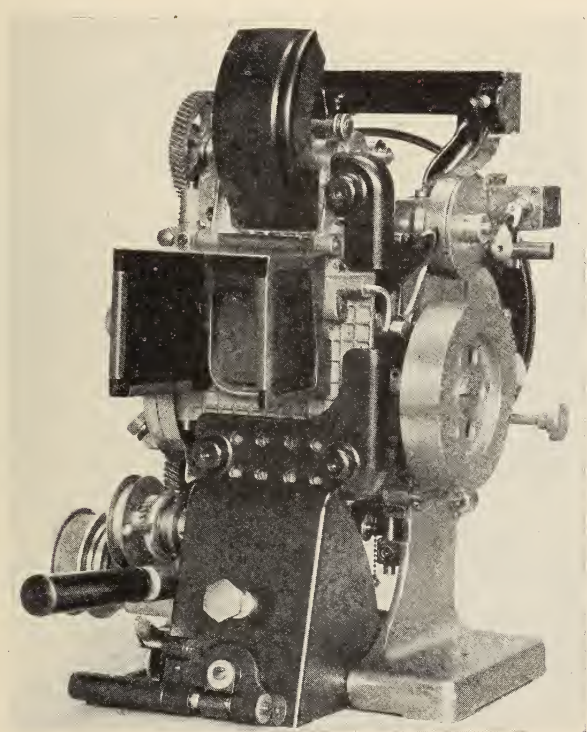


FIG. 2. New Power's Gate Closed.

The fire shutter is composed of a die cast bronze counterbalance to which is attached a heavy steel curtain so mounted as to pivot with the action of the fire shutter governor. This shutter has a positive stop and is so designed as to open and close at a film speed of approximately fifty crank turns per minute so that it is rigidly held open at normal projection speed. Should the spot be left continually on this fire shutter, it is impossible for the film to become overheated or damaged inasmuch as there is approximately $\frac{3}{8}$ inches of air space between the shutter and

the first plate aperture the fire shutter itself being approximately $1\frac{3}{4}$ inches from the film. With such a great amount of heat playing on the gate it is, of course, impossible to keep the front plate cool, and as a matter of fact it reaches a temperature close to the boiling point of water. The projectionist's hands coming in contact with such a hot structure would naturally be subject to severe burns, and in order to overcome this undesirable condition moulded bakelite insulating plates have been attached in such positions as to render discomfort to the projectionist impossible. At the same time these bakelite insulating plates, which are entirely insulates from the metal structure, serve as a positive protection for the film inasmuch as under no condition can it come in contact with the heated surface of the front plate. Fig. 3 shows the new type gate and lower fire shield open.

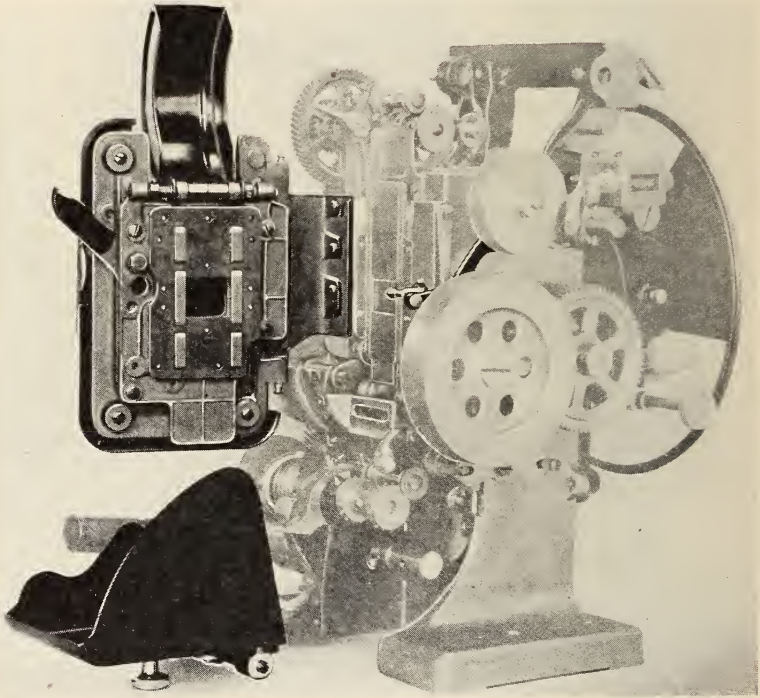


FIG. 3. New Type Gate, Open.

Rigidly attached to this front plate is a central plate to which is attached the insulated trip lever and gate latch, the upper fire shield, the lateral guide rollers, the film pad plate and the tension shoes, together with their respective tension springs. Between the front plate and the central plate, and the central plate and the tension shoe pad plate, considerable air space has been provided so that a rush of cool air at all times is assured, which serves to keep the equipment moderately cool. The film pad plate is of heavy cold rolled steel, to which are

attached the film tension shoes and tension springs and, as before stated, these are far removed from the source of heat and thoroughly protected so that there is no danger of the tension changing due to temper being drawn from the springs. There are six tension pads or shoes, each acting independently of the other, in place of the solid single unit of great length as heretofore used. These pressure pads are of hardened steel, highly ground and polished. These pads are placed on either edge of the film above and below the aperture, and their function is solely to hold the film steady against the pull of the intermittent sprocket. The other two pressure pads are placed one on either edge of the film at the aperture, and just sufficient tension is maintained on them to hold the film perfectly flat and in focus over the aperture. The edges of the shoes are ground to eliminate

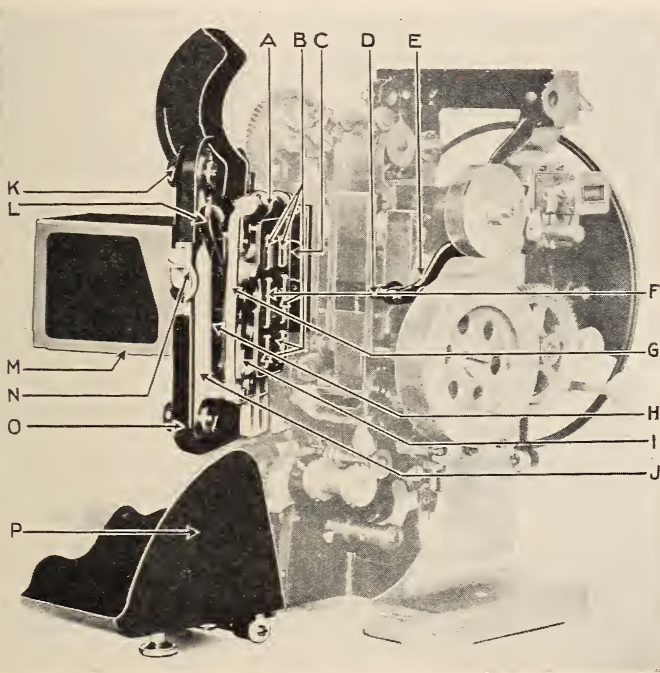


FIG. 4.

danger of scoring the film due to any slight burrs which might otherwise be left upon them, and the tension springs where they come in contact with these pads have a slight radius so that the pads are free to pivot upon them. The pads, therefore, are brought in absolutely flat contact with the film at all times.

The entire gate assembly is supported by an exceptionally rugged hinge securely and rigidly attached to the mechanism frame in such a manner that there is no possibility of lateral or vertical lost motion, and through the addition of a substantial latch the gate when closed is firmly locked in position so that the

pressure pads exert the same amount of tension on the film at all times. In addition to the old gate having been discarded, the old type lower fire guard or shield has also been eliminated, and in its place is a film guard of much more satisfactory design and so constructed that instead of opening laterally it drops vertically entirely out of the way so as to leave the mechanism free from obstructions while threading the film. This guard when in its normal operating position is locked securely in place by means of a gravity operating lock so placed that when it becomes necessary for the projectionist to lower the film shield his finger automatically comes in contact with the latch, readily lifting it from the latch bar.

The lettered parts in Fig. 4 are described below:

A. Lateral guide roller.

B. Upper and lower film pads. These pads are of hardened steel, ground, highly polished and beveled and so held under tension as to assure a square contact with the film at all times. They are maintained under sufficient tension to insure perfectly steady projection and no adjustment is necessary.

C. Film plate pad to which is attached the upper and lower film pads together with the central film pad and their respective tension springs.

D. Gate lock screw.

E. Fire shutter lift lever. A newly designed link between the fire shutter governor and the fire shutter proper.

F. Central film pads. These pads are maintained under lighter pressure than B, and their sole function is to keep the film in focus over the aperture. These pads, like the upper and lower film pads, are of hardened steel, ground and highly polished.

G. Rear baffle plate. This plate is rigidly attached to the front or support plate and carries the lateral guide roller, upper film shield gate latch, insulated trip lever, gate stop, and film pad plate assembly.

H. Air space between G and J.

I. Air space between G and C.

J. Front plate (radiating and insulating heat shield). This plate is designed to eliminate warpage under severe heat.

K. Upper heat insulating cap.

L. Insulated gate latch lever.

M. Light shield to protect the projectionist's eyes from the intense spot on the aperture.

N. Fire shutter pivot pin.

O. Lower heat insulating cap.

P. Lower loop protector.—This newly designed assembly is self-locking and is so constructed that it opens downward rather than laterally as in the former design.

DISCUSSION

MR. KUNZMANN: I should like to ask in the absence of Mr. Griffin whether the new accessories are adaptable to all models of Powers projectors.

MR. MCGUIRE: They are.

CARBONS FOR USE WITH PANCHROMATIC FILM

E. R. GEIB*

At the spring meeting of this Society held at Norfolk, Va., Mr. M. J. Dorcas of our research laboratory mentioned in his paper on the subject "Physiological Effects of Light" that some experimental work was being conducted on carbons for use with panchromatic film. This type of carbon was referred to at that time as the "orange flame" and was later given a number, namely 42661. Since then, additional work has been done, and the National Carbon Company now wishes to announce a line of panchromatic carbons.

By the introduction of certain materials in the cores of carbons, it is possible to influence the characteristics of the light very materially. A series of carbons has now been developed which give the user the advantage of a wide range of lighting effects. This series begins with carbons giving light which predominates in the shorter wave-lengths and ends with carbons giving light rich in the longer wave-lengths. Perhaps the best way to visualize the light which is obtainable from these different carbons is to see several arcs in operation. We have accordingly trimmed six arc lamps with carbons showing the different modifications of light quality which are possible.

Demonstration

Lamp No. 1 has been trimmed with the well known National white flame carbons. The light from this arc you will observe is bluish white. This light is particularly rich in the short wave-lengths; that is, blue, violet, and near ultra-violet. The Bureau of Standards found this carbon to be the closest approach to sunlight of all artificial illuminants.

Lamp No. 2 has been trimmed with an experimental carbon which is a modification of the "white flame" in that while emitting a light which is strong in the blue, violet and near ultra-violet is stronger in the red and green than the "white flame" arc. It will be observed that there is not so much blue in this light.

Lamp No. 3 is trimmed with carbons which emit still less blue, violet, and near ultra-violet and more of the longer wave-lengths of light as evidenced by the yellowish tinge.

Lamp No. 4 is trimmed with carbons which give a deeper yellow light than No. 3 indicating a greater amount of light in the long wave-lengths.

Lamp No. 5 is trimmed with carbons which produce an orange colored light. There is more of the red in this light than in that given by the carbons used in lamp No. 4.

Lamp No. 6 is trimmed with carbons giving a reddish orange colored light.

Thus, it will be seen that by changing the ingredients in the cores of the carbons we can vary the light to a marked degree. Any one type or grade of these carbons can be supplied in sizes to meet the requirements of the high powered arc lamps now in use in the production of motion pictures.

*National Carbon Co., Cleveland, Ohio.

DISCUSSION

DR. GAGE: Do any of these carbons correspond to some of the older and well known carbons? The first is like the white flame; does another correspond to the yellow flame or are they all different?

MR. GEIB: No. 1 is the white flame; No. 4, if I remember correctly, is the so-called yellow; No. 5, the orange, and No. 6, the red. There may have been changes in the chemicals, but I believe those are essentially the colors.

MR. RICHARDSON: I believe this demonstration means a great deal. Ten or more years ago when I made the statement in print that this very thing could be done, I was derided and even laughed at. I believe it only remains for carbon manufacturers to make this method of light tone modification available to motion pictures to enable us to have exactly the light source we need. The whites are now altogether too "chalky" on our screens. The high intensity light source is not well adapted to color projection; also it has objectionable features for black and white.

When I was in Baltimore many years ago I visited a small theater in which a most unusual screen illumination was obtained from an AC light source. I was advised by the projectionist that it was a result of soaking the carbons several days in a strong salt solution. I immediately advised the National Carbon Company of what I had seen and of the reasons ascribed by the projectionist. The company advised me that it was extremely unlikely that light tones could be materially changed by impregnation of the carbons with substances designed to give that result because of the fact that they would be volatilized instantly by the terrific heat of the crater. Notwithstanding the ideas then held, we all know that the National Carbon Company has accomplished much in that direction already and probably will accomplish very much more. We need a light source better adapted to projection than anything we have as yet been offered, and in my opinion this demonstration points the way.

MAZDA LAMPS FOR MOTION PICTURE PHOTOGRAPHY

R. E. FARNHAM*

The ability of panchromatic film to render various colors to a very much better advantage has resulted in its general use for motion picture photography. To derive the full possibilities of this film, however, it must be used with a light source which has a greater proportion of red, orange, and yellow than of blue and violet. The light of incandescent tungsten at a temperature of from 3000 to 3250 degrees *K* possesses color characteristics which make it particularly well suited to bring out the full value of panchromatic film, with the result that most of the larger studios are turning to the use of incandescent lamps. There will shortly appear pictures produced by the various studios made on panchromatic film and lighted by mazda lamps.

The particular points of advantage which the studios find are:

1. The greater control of the light flux and the higher efficiency of utilization that can be obtained

*National Lamp Works, Cleveland, Ohio.

2. The very small staffs which suffice for handling the light
3. The instant availability of the light
4. The opportunity to increase the intensity of light by change of voltage during the action and the maintenance of a perfectly clear atmosphere at all times.

All of these have a definite effect in expediting the work on a picture and in reducing the cost of production.

In order to determine the lighting requirements in making motion pictures, the lamp engineers have gone into the studios and have obtained data which will permit the design of the most efficient and satisfactory lamp and suitable equipment.

For the purpose of lamp and equipment design, the lighting of the greater proportion of the "sets" can be grouped under two headings: a general or "soft" illumination and the modeling or "hard" lighting. In the general lighting of the set, a uniform flood of illumination is directed to all parts of the set. This lighting should not model the subject in any way but should provide a general even illumination to serve as a foundation for the modelling lights. This form of lighting is usually accomplished by the use of "broad-sides" and overhead units. The "broad-sides" are required to provide a uniform illumination through an angle of approximately 60 to 90 degrees. These units are generally placed across the front of the set. The overhead lighting is provided by the use of "scoops" and "domes" and supplements the "broad-sides" in illuminating the rear of the set.

The 1000-watt and 2500-watt PS-52 bulb clear lamps have proved most satisfactory for this service. Most of the studios are at present using equipments which are adaptations from old units but more efficient lighting results can be obtained with the use of equipment designed particularly for the incandescent source. The mistake should not be made of using a higher priced concentrated filament lamp for this source when the less concentrated types are better.

After a general illumination has been provided, a light of some two to four times the general room intensity is directed on to the actors usually from the rear and sides and frequently from the front for the purpose of producing high lights and stronger contrast so as to give depth to the picture and make the actors stand out. This lighting is accomplished by the use of spot lights, and for this purpose the 2000-watt G-48 bulb and 5000-watt G-64 bulb lamps with concentrated filaments have proved themselves satisfactory. These lamps are generally used in search light type units with accurately ground parabolic reflectors. Where very strong high lights are required, such as would be obtained from sunlight, the 10,000-watt in a 24-inch parabolic reflector unit has given considerable success. Equipment which will redirect light efficiently within the proper angle and suited especially to the physical characteristics of Mazda lamps is now being developed.

DISCUSSION*

MR. RICHARDSON: What is the candle power of the lamp?

MR. FARNHAM: The mean spherical candle power of the ten-kilowatt lamp is approximately 23,000. In a direction perpendicular to the plane of the filament it is 35,000 candle power.

MR. CUFFE: Do you have to light it through a rheostat?

MR. FARNHAM: This lamp should be "warmed up" at from 40 to 70% rated volts for about 20 seconds before the full line voltage is turned on.

DR. GAGE: What is the color temperature of the filament?

MR. FARNHAM: It is about 3000° Kelvin for the 10-kilowatt lamp.

MR. RICHARDSON: What is the degree of vacuum?

MR. FARNHAM: These lamps are gas filled to a pressure of about 600 mm. as compared to atmospheric pressure of 760 mm.

MR. RICHARDSON: What is the vacuum of an ordinary incandescent lamp; what percentage is the evacuation?

MR. FARNHAM: The vacuum lamp has a pressure of about 1/10,000,000 of a millimeter. In other words, only about 0.00000013% of air remains in the lamp.

MR. BAUER: What is the life of the lamp?

MR. FARNHAM: The rated life of the 10-kilowatt lamp is 100 hours.

MR. BAUER: We had a few of these at the Famous-Players studio and they didn't last more than 10 hours.

MR. FARNHAM: The 10-kilowatt lamp was originally developed for lighting of aviation landing fields, and it was found to have a useful application in motion picture photography; hence, the lamp has been used to some extent for this work. However, the different operating conditions which the lamp encounters in studio service has resulted in many early failures. The lamp manufacturers are altering the design of this lamp so as to make it practical for studio work.

MR. CUFFE: How does this compare with the straight arc on the tilt?

MR. FARNHAM: Tests which we have made of the broadside arcs show it to give about 13,000 candle power directly in front of the unit. The maximum power of 10-kilowatts is about 35,000. However, this is without any reflecting equipment used in conjunction with the lamp. The side arc and the 10-kilowatt lamp can hardly be compared because their applications in motion picture photography are widely different. The 1000 and 2500 PS-52 bulb lamps, when used in conjunction with suitable equipment, give even greater light output than the side arc.

THE MODEL 3 VICTOR CINE CAMERA*

The latest Victor product, designated the model 3 Victor cine-camera, incorporates with the usual features deemed standard for amateur cameras several new and useful accomplishments. Foremost among these is an adjustment for speed of the mechanism, permitting the taking of slow-motion and normal pictures alternately on the same film. The ultra speed for slow-motion is regulated in the stock camera to 4 times normal, this being determined the practical speed for amateur-made slow-motion pictures. A half turn of the operating button accomplishes the change from one speed to the other. The speed may also be regulated to half normal. The operating button may be locked down on normal speed to permit the operator to enter his own picture. Also it may be locked in non-operating position to prevent running film accidentally when the camera is not in service.

*Victor Animatograph Co., Davenport, Iowa.

The Victor camera is driven by a duplex spring motor, three windings of which will run through 100 feet of film. The spring winds very smoothly and quickly with the same crank which serves for operating the camera by hand. Automatic stops prevent excessive winding or unwinding. Starting and stopping even when set at high speed is accomplished very silently and smoothly and without vibration. The shutter covers the aperture when the mechanism stops.

Provision is made for using interchangeably the several makes of lenses now offered the amateur trade for 16 mm. cameras. This list includes the several focal lengths between one and six inches, and the varying speeds up to $f/1.5$. The exposure meter is built into the door. The correct diaphragm settings of the usual average scenes under varying light conditions are given by a direct-reading movable indicator.

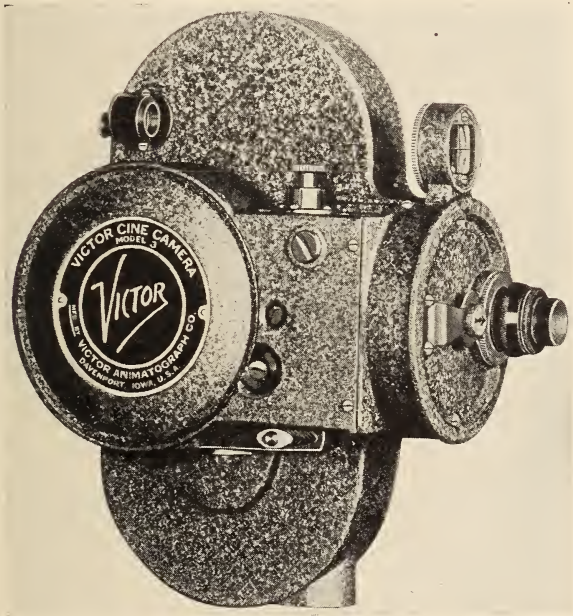


FIG. 1. Victor Cine Camera Model 3, Side View.

Another innovation is the compensating view finder of the telescopic type. The sight is adjustable for distance to correct the angle of error between the finder and taking lenses. This eliminates the need of supplementary finder attachments for use with telephoto lenses.

To prevent the taking of "up-hill" pictures, a pendulum level registers with the vertical etched line of the finder lens.

An automatically set film measure registers the footage of unexposed film in the camera.

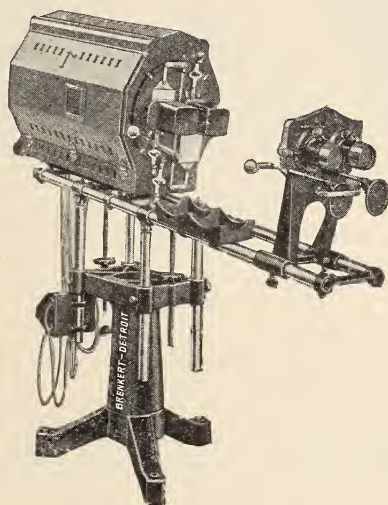
The film driving mechanism has been very greatly simplified. A single claw action is permanently synchronized with the shutter. One feed sprocket only is used.

The convenient location of the view finder and operating button makes the Victor cine-camera very easy to hold and operate.

The instrument is constructed of die cast aluminum; the weight complete is $4\frac{3}{4}$ pounds; the size is $3\frac{1}{4}$ by 8 by 6 inches.

*Advertising
Section*

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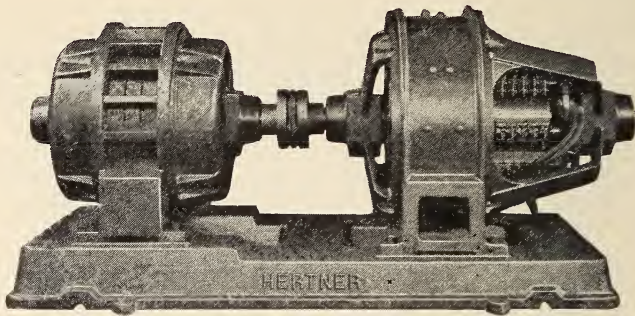


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ACTIVE MEMBER—An Active member shall not be less than 25 years of age and shall be:

- (a) A motion picture engineer by profession. He shall have been in the practice of his profession for a period of at least three years and shall have taken responsibility for design, installation, or operation of systems or apparatus pertaining to the motion picture industry.
- (b) A person regularly employed in motion picture or closely allied work, who by his inventions or proficiency in motion picture science or as an executive of a motion picture enterprise of large scope, has attained a recognized standing in the motion picture art. In the case of such an executive, the applicant must be qualified to take full charge of the broader features of motion picture engineering involved in the work under his direction.

ASSOCIATE MEMBER—An Associate member shall not be less than 21 years of age and shall be:

A person who is interested in or connected with the study of motion picture technical problems or the application of the same.

When, in the judgment of the Board of Governors, an applicant is not suited for the grade of membership for which he has applied, but is eligible to the other grade of membership, the applicant shall be so notified by the Secretary and shall be given the opportunity of changing his application accordingly.

No application shall be approved by the Board of Governors until they have satisfied themselves of the fitness of the applicant.

Applications should be mailed to the Chairman of the Membership Committee or to the Secretary. When the applicant is accepted for membership by the Board of Governors he will be so notified, in writing, by the Secretary.

All checks should be made payable to **SOCIETY OF MOTION PICTURE ENGINEERS**.

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The entrance and transfer fees, payable on admission to the Society, or upon transfer, are as follows:

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