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TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

CONTENTS

Number Twenty-five

MEETING OF MAY 3, 4, 5, 6, 1926

WASHINGTON, D. C.

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OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

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MEETING OF MAY 3, 4, 5, 6, 1926
WASHINGTON, D. C.

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PROGRESS IN THE MOTION PICTURE INDUSTRY

1925-1926 Report of the Progress Committee

Introduction

A STUDY of the progress in the motion picture industry for the past six months reveals no outstanding developments of a revolutionary nature. This industry, like the radio and automobile fields, appears to be entering upon a period of improvements and refinements.

Many new uses are being found for motion pictures. Generally these are of a utilitarian nature rather than for entertainment, but a most unique application is the use of pictures in the detection of election frauds.[1] At an election recently held in France, one of the parties found that in a given district the vote had increased 20 per cent over the previous year. As only five days are allowed to claim fraud, the problem was to find some method of checking the voters' list and obtain verification of the names. The voters' lists were photographed on motion picture film and projected on to a screen which was divided off into a number of sections. A staff of 300 addressers copied down the names and a return postcard was sent to each voter. Two days after mailing, 18,000 were returned to the senders marked by the post office "dead," "not known," "removed," etc.

Contrasted with the recent successful efforts in this country to remove the government tax on motion picture theatre tickets, municipalities in Poland[2] are placing an increasing burden on photoplay houses. The tax in some cases amounts to as high as 50% total receipts with the result that, whereas in 1924 there were 800 theatres, this number was reduced in 1925 to 500 and to only 383 at present. Norway pursues another method[3] of obtaining revenues from its motion picture theatres; here 118 of the 252 theatres in operation at the close of 1925 were publicly owned. These 118 theatres reported a gross income of 12,750,000 crowns ($3,217,000) as compared to 1,686,000 crowns ($442,000) for the 134 privately owned houses.

[1] "American Projectionist," October, 1925, p. 6.

[2] "Motion Picture News," April 3, 1926, p. 1501.

[3] "Motion Picture News," April 3, 1926, p. 1497.

In general, much more attention has been given in the industry to the mechanics of projection than to the setting for the screened picture. Along the lines suggested by one of our members several years ago,[4] a writer proposes that to make the projected picture more realistic and to better convey the true illusion, the screen be set in a background of uniform hue which should be second in brightness to the picture itself. The eye will work at a normal aperture and the true contrasts be preserved in the shadows of the pictures. The illusions of warmth, distance, or night now conveyed by tinted film would be diminished or decreased at will by altering the color in the background.

Respectfully submitted:

C. E. Egeler, *Chairman*
J. I. Crabtree
W. V. D. Kelly
Rowland Rogers
Kenneth Hickman

Cameras

Two new motion picture cameras of the portable spring-operated type have recently appeared on the market.[5, 6] Both are adapted to professional use and will be used largely to supplement the regular standard cameras, particularly where quick action is desired. A new professional camera[7] has recently been placed on the market which automatically changes its iris diaphragm during the exposure of each frame. Another lightweight camera of low price[8] has been introduced and is made to sell in units. Extra lenses, magazines, and special attachments will be sold separately, so that to meet his requirements the individual may assemble a complete equipment from standard parts.

To take care of a great variety of conditions which may arise while filming motion pictures, there has been developed a new iris[9] diaphragm which may be used on any standard camera. It is equipped with a bellows extension, sky filter, gauze mat box, four-way slide

[4] "Photographic Journal," July, 1925, p. 355.
[5] "American Cinematographer," September, 1925, p. 5.
[6] "American Cinematographer," December, 1925, p. 16.
[7] "Film Technik," July 5, 1925, 1, p. 17.
[8] "American Cinematographer," December, 1925, p. 13.
[9] "American Cinematographer," February, 1926, p. 20.

gauzes, and four-way solid matting plates. Another type of masking device[10] recently developed consists of a large disk fitted with various sized masks which can be successively placed in front of the lens by rotating the disk. A combination long-shot, close-up camera[11] has been developed by the simple expedient of mounting one camera on top of another. This permits the simultaneous taking of long-shots and close-ups, and it may be rotated 360 degrees without one camera interfering with the other. For the purpose of taking motion pictures[12] of rapidly moving objects quite close to the camera, a motion picture camera has been developed in France which uses a focal plane shutter. A small projector and camera especially for the amateur motion picture photographer has been made available which uses a special narrow width film,[13] smaller than the standard 16 mm width and which can be redeveloped to form a positive.

Color Photography

A perusal of both the American and European patents shows continued activity on the part of the inventors towards developing various methods of making colored motion pictures. German investigators[14] have found that the pigment and pinatype processes for coloring lantern slides give excellently colored slides. High wattage incandescent lamps have been used successfully for taking colored motion pictures;[15] the methods and equipments are described in a paper presented before this Society.

Film Printing

In a series of tests conducted in one of the French cinema[16] research laboratories, it has been found that very little difference exists between positive prints produced by diffused light (from a large source) and those produced by direct light (from a small source) except in the case of very coarse grained emulsions.

[10] "Film Technik," July 25, 1925, 1, p. 61.
[11] "American Cinematographer," March, 1925, p. 9.
[12] "British Journal," August 21, 1925, 72, p. 500.
[13] "Transactions," S. M. P. E., March, 1926, p. 147.
[14] "Photographische Rundschau,", July 1, 1925, 62 p. 255.
[15] "Transactions," S. M. P. E., September, 1925, p. 25.
[16] "British Journal," August, 1925, 72, p. 474.

Films and Emulsions

The chief source of loss[17] in film manufacture lies in the rejection of imperfectly coated stock, especially at the ends and edges of the rolls after coating. These losses together with those caused by spots and mechanical imperfections may amount to over 25 per cent. The former loss can be diminished by coating as widely as convenient and in very long lengths without stopping. Even with every precaution, not more than 80–85 per cent yield figured on the raw base can be obtained. Since the yearly production of motion picture film is estimated at 500,000,000 meters (1,640,000,000 feet), the total losses are very large although the silver and bromine and sometimes the film base are recovered. It is suggested that less rigid standards might contribute to lower costs without serious objection by the public. In this same connection[18] a German writer discusses what he believes to be the best type of building for the processing of motion picture film. The top floor is used for chemical storage, the third floor for mixing solutions, the second for storage, and the first for developing machines. Filters, circulating pumps, and silver recovery equipment are in the basement.

It has been found[19] that good results may be obtained with as little as one-fourth the usual amount of light in exposing film which has received a pre- or after-exposure. Film[20] may be made to slide more easily by coating that part of the surface of the film not covered by emulsion with a finely divided lubricating material, such as a colloidal solution of sodium stearate.

A German writer[21] has found that the standard 16 mm. film and the reversal development is satisfactory and has recommended its universal adoption as the amateur standard for that country.

For the amateur[22] who likes to develop his own films and who also possesses equipment using narrow width film, a home-developing outfit has been produced. This process consists in first developing the film in a paraphenylene-diamine compound, then bleaching in potassium permangante, and redeveloping in sodium sulphite and sodium hydrosulphite solutions.

[17] "Photographische Industrie," September 14, 1925, p. 1023.
[18] "Kinotechnik," September 25, 1925, 7, p. 449.
[19] "Schweizerische Photo-Zeitung," September 11, 1925, 27, p. 352.
[20] French patent No. 595179.
[21] "Kinotechnik," September 25, 1925, 7, p. 421.
[22] "British Journal," July 17, 1925, 72, p. 432.

Papers have been presented before this society which describe a machine[23] for the complete development of negative and positive motion picture film, methods[24] of washing film including formulæ which enable the operator to determine the length of time to completely free the film of hypo, and the procedure[25] necessary to eliminate rack marks and air bell markings from the film as it is being washed and developed. Another writer[26] shows that wide splices are no stronger than narrow ones when properly made. Correct splices are necessary, however, to aid in the easy passage of the film over the sprockets and through the guides.

General

A well known theater [26a] chain has inaugurated a school for the purpose of training theater managers. A course of study lasting six months includes all phases of theater management.

For the theater manager who likes to be up to the minute in his knowledge of box office receipts, a device[27] has recently been marketed which may be placed in his office, connected to the ticket selling machine in the ticket booth to give a minute to minute record of the tickets sold.

Mathematicians have attacked the problem of determining correct exposures.[28] As a result, a mathematical expression has been developed in connection with the taking of photographs of rapidly moving objects to determine the correct exposure, knowing the value of the various factors which influence it.

A Japanese scientist[29] has invented a black glass supposed to be opaque to all but ultra-violet rays. It is claimed that motion pictures may be taken in the dark using this type of glass.

The following claims are made for a small device invented[30] by an American: Stereoscopic pictures with depth dimensions, perfect shots in rain or fog, scenes through a plate glass window, scenes of an object fifty miles distant, faultless pictures of actors without

[23] "Transactions," S. M. P. E., September, 1925, p. 46.
[24] "Transactions," S. M. P. E., January, 1926, p. 62
[25] "Transactions," S. M. P. E., March, 1926, p. 95.
[26] "Transactions," S. M. P. E., March, 1926, p. 131.
[26a] Catalog of Publix Theater Manager School.
[27] "Motion Picture News," March 20, 1926, p. 1323.
[28] "American Photography," July, 1925, 19.
[29] New York Herald-Tribune, October 6, 1925.
[30] "Motion Picture News," March 20, 1926, p. 1322.

make-up; this device attached to an ordinary camera permits the elimination of strong lights and thus does away with Klieg-eye. Details are lacking.

Surprising as it may seem, there is more actinic light[31] in England than in southern France. The variability of the British climate, while difficult to judge because of fog, affords opportunities for unusual scenic effects. Motion pictures taken entirely by infra-red radiations[32] have shown some very interesting results.

Illuminants

French studios[33] are experimenting with some new types of incandescent lamps for studio lighting. They are using wattages of 3000 and 4000; the lamps have tubular bulbs.

A new prefocusing base[34] and socket has been developed for medium base projector lamps. The base consists of two parts, an inner shell which is based to the lamp in the usual manner and an outer shell which is soldered to the inner shell so that it always bears a fixed relation to the filament. When the lamp is inserted in its special socket, it is automatically aligned.

A 500-watt incandescent projection lamp[35] recently made available is particularly applicable to motion picture and stereopticon projectors of the portable type. It is designed for an average rated life of 50 hours and gives approximately one-third greater screen illumination than the 400-watt lamp which had heretofore been standard for this service. In Germany, a 600-watt, 15-volt lamp[36] has been made available for which approximately 30 per cent greater screen illumination than that received from the familiar 30-volt lamp of the same wattage is claimed.

German investigators have been making a comparative study of the relative advantages of vapor (high intensity) and mirror arcs. It is reported[37] that the mirror lamp though more economical is difficult to operate and is dangerous through over-heating when used with old style projectors.

[31] "Kinematographic Weekly," October 15, 1925, 104, p. 84.

[32] "Transactions," S. M. P. E., September, 1925, p. 21.

[33] "Bulletin de la Société Française de Photographie," May, 1925, 12, p. 104.

[34] "Light," December, 1925, p. 46: "Transactions," S. M. P. E., January, 1926, p. 39.

[35] "Light," November, 1925, p. 32.

[36] "Filmtechnik," August 5, 1925, 1, p. 83.

[37] "Kinematographic Weekly," August 3, 1925, 103, p. 75.

A device[38] has recently been developed for use with the high intensity arc which permits a second carbon to be placed in the projector immediately behind the first so that the amount of waste carbon is reduced from 4½ inches to 1½ inches.

The requisite brightness[39] of the projected picture has been the subject of mathematical analysis with the result that a relation between the illumination, time of exposure, and screen brightness has been evolved.

In a paper[40] presented before this society, the limitations and possibilities of the reflectors for motion picture arc lamps are discussed. It would appear that of the various types of mirrored surfaces employed, the elliptical reflector offers the greatest number of advantages. Comprehensive data[41] relative to the several types of high intensity arcs showing the lumens output and spectro-metric analysis have also been presented. Another writer describes a special incandescent spotlamp[42] employing a condensing and objective lens in a manner similar to a stereopticon projector and an adjustable iris diaphragm in place of the usual slide to control the spot size. An experimental ribbon filament incandescent lamp is used.

Lenses

A prominent German lens manufacturing firm[43] has made available a new motion picture lens which has speeds of F/3.5 and F/3.0 and is composed of three single elements. It is made in several focal lengths for both the standard 35 and 16 mm motion picture cameras.

In order to take motion pictures at a distance[44] of 3.5 kilometers (2 miles) a German cinematographer uses an ordinary telescope which is focused on the object; the usual telephoto lenses are not sufficient. Panchromatic film with yellow filters is recommended.

Motion Picture Applications

A French concern[45] has arranged two automatic motion picture

[38] "American Projectionist," February, 1926, p. 6.
[39] "Photographische Industrie," May 4, 1925, p. 505.
[40] "Transactions," S. M. P. E., January, 1926, p. 94.
[41] "Transactions," S. M. P. E., March, 1926, 71.
[42] "Transactions," S. M. P. E., March, 1926, p. 113.
[43] "Photographische Industrie," August 24, 1925, p. 93.
[44] "Kinotch. Rundschau," April, 1925, p. 30.
[45] "British Journal," June 19, 1925, 72, p. 363.

cameras at the two ends of an exactly measured base line of about 1500 meters (4600 feet). These instruments make simultaneous photographs of the clouds, recording at the same time the exposure, time of day, and the vertical and horizontal position of the apparatus, from which data the cloud position may be determined.

In projecting images of stars and of the edge of the sun's disk,[46] tremors may be noticed which are often rhythmical and owe their origin to atmospheric irregularities in the higher regions. These waves precede storms, and their study may be of great benefit in weather prediction. Motion pictures have been taken of this phenomenon, and a study of these pictures has yielded important results.

An Italian engineer[47] has recently developed a device for taking motion pictures at from 3000 to 6000 feet under water. In another scheme a steel cylinder[48] carrying two men, oxygen purification apparatus, and a motion picture camera has made possible the taking of motion pictures at the bottom of the sea. Small propellers are provided for turning the cylinder, and a searchlight fitted with a quartz arc lamp provides the illumination.

In the field of medicine, motion pictures are being used quite extensively, particularly in the photography of operations. These pictures are much more effective for instruction purposes than the usual clinics. One well-known medical lecturer[49] uses a spotlamp equipped with an incandescent lamp, and the intensity received is sufficient for clear pictures with lens stopped down to F/4. A portrait lens is used in conjunction with the regular camera lens to permit placing the camera close to the subject so as to obtain large pictures.

Passengers[50] on the Philadelphia-Asbury motor bus line are being entertained with motion pictures during the night runs. The pictures are thrown on the screen placed behind the driver's seat.

Motion pictures[51] are being used to a great advantage in photographing the interior of a rifle barrel. A very small lamp fastened to the end of a rod contains a series of prisms and illuminates the interior of the barrel; the image is directed on to a motion picture film which is moved in synchronism with the movement of the ex-

[46] "Photographic Journal," February, 1925, 65, p. 362.
[47] "Revue Française de Photographie," March 1, 1925, 6, p. 60.
[48] "Kinotechnik," September 25, 1925, 7, p. 457.
[49] "The Ciné-Kodak News," April, 1926, p. 3.
[50] "Cleveland Plain Dealer," April 12, 1926.
[51] "Scientific American," March, 1926, p. 162.

ploring lamp and lens through the barrel. The pictures are said to be a valuable adjunct in determining the amount of wear on various types of barrels.

A Viennese opera composer[52] has reversed the usual order and has written a motion picture scenario to fit an opera. The action of the film is carefully timed to fit the theme as played by the music. This development will undoubtedly be aided by another invention by means of which orchestra cues[53] appear directly on the conductor's desk, being controlled from the projector.

Physiology

The time honored contention that motion pictures are injurious to the eyes is discussed conclusively in papers[54] presented at the Convention of the American Medical Association. It is contended that the eye suffers less fatigue from viewing motion pictures than it does from reading plain print for even a shorter time. However, sitting too close to the screen[55] is harmful because of the strain on the eye muscles in following the movement of the picture at too wide an angle.

Tests[56] to determine the effect of light from various sources upon the eye show that conjunctivitis is promoted by ultra-violet light, and the use of arc lights without enclosing globes is condemned.

Projectors (continuous)

A perusal of recent patents shows that the continuous motion picture projector still holds the interests of many manufacturers as well as inventors. The usual systems require either a multiplicity of lenses or of mirrors to keep the image in register as the film moves. Word of a projector of this type that shows promise comes from Germany. The image of the aperture is reflected by a plane mirror[57] to a rotating continuous ring mirror cut from the surface of a sphere. The ring is cut at one point and the ends offset so that a discontinuous image is given. From this a second plane mirror directs the light through the objective lens.

[52] "New York Times," January 12, 1926.
[53] "Scientific American," October 25, 1925, 133, p. 232.
[54] "Cleveland Plain Dealer," April 26, 1926, p. 1.
[55] "Exhibitors Herald," December 26, 1925, 24, p. 32.
[56] "Educational Screen," November 1925, 4, p. 520.
[57] "Photographische Industrie," June 15, 1925, p. 669.

Projectors (intermittent)

Since film burns so much more rapidly in an upward than in a downward direction, it has been suggested that the film magazine normally on top of the projector be placed alongside of the take-up magazine, thus removing the film to a place of less danger in event of fire.[58]

Methods of cooling the beam of light[59] before it reaches the film aperture continue to appear. One arrangement consists in placing a number of metal rods longitudinally in the light beam between the source and the film aperture. These are in turn connected to a tank of circulating water. A large number of tests[60] made on various types of cooling systems show that cool moist air of 80-95 per cent humidity was most effective in lowering the temperature and increasing the projection life of the film. Without cooling, the film base decomposed first, but with an air blast the emulsion layer was destroyed before the base. An air blast tended to prevent open flames breaking out.

If the film guides[61] and rolls are made of bakelite, unwaxed green film can be projected without sticking or scratching. A German writer describes the home projector[62] as he sees it in the future. The apparatus will be used in a cabinet resembling a phonograph and will handle the usual 35 mm film with perfect safety. It will be motor-driven and semi-automatic in operation.

Screens

An unusual motion picture screen[63] described in a German publication consists of a surface composed of colored strips continuously moved by two cylinders. Pictures projected on to this screen are said to be more intense in daylight than pictures projected on an ordinary screen in a darkened room. An artificial cloud[64] or mist produced by a spray has been used as a projection screen for the projection of motion pictures in a Berlin park. Another screen[65] developed

[58] "Transactions," S. M. P. E., March, 1926, p. 66.
[59] German patent No. 416807
[60] "Photographische Industrie," May 18, 1925, p. 561.
[61] "Filmtechnik," November 25, 1, and December 5, 1925, pp. 323 and 341.
[62] "Filmtechnik," September 25, 1925, 1, p. 201.
[63] "Kinematographic Weekly," July 2, 1925, 100, p. 69.
[64] "Photographische Industrie," July 20, 1925, p. 803.
[65] "Kinematographic Weekly," July 2, 1925, 110, p. 69.

by an English inventor is made of mottled opal glass. It is built in sections which fit together, leaving the cracks invisible to the observer. The screen is permanent and washable.

Standardization

At the International Photographic Congress[66] in Paris, the Cinematographic Section devoted considerable discussion and study to various types of negative perforations and film sprockets. Dimensions for the projector and camera sprockets, the film aperture, and the sprocket holes of both negative and positive film were tentatively agreed upon subject to six months' consideration.

Statistics

The Department of Commerce[67] reports that during the month of January, 1926, $790,000 worth of film was exported. Canada was the largest consumer, taking over 1,900,000 feet of positive film valued at $75,000 together with 235,000 feet of unexposed film with a total value of $19,000. Other large users of American film for the month are France, Argentina, Brazil, and Australia. The total exports[68] for the year of 1925 amounted to 30,000 miles of film.

According to the latest report[69] compiled by the United States Census Bureau, the value of the combined output of motion pictures was $88,418,170 for 1923 or an increase of almost 11.7 per cent over 1921. There was a decrease of 10 per cent in the number of persons engaged in the industry and a 50 per cent decrease in the number of proprietors. Of the 97 establishments reported for 1923, 47 were in California, 16 in New York, 8 in New Jersey, 7 in Illinois, 5 in Pennsylvania, 3 in Michigan, and the remaining 10 in several other states. California, the leading state, reported 62.9 per cent of the total value of the output for 1923.

While there are more seats, there are fewer motion picture theatres[70] than in New York City in 1924, according to the report of the Bureau of Licenses of that city. Brooklyn leads with 224 houses,

[66] "Film Technik," July 25, 1925, 1, p. 52; "Kinotechnik," August 10, 1925, 7, p. 361; "Kinotechnik," June 25, 1925, 7, p. 283; and "Transactions," S. M. P. E., March, 1926, p. 29.

[67] "Motion Picture News," April 10, 1925, p. 1585.

[68] "American Projectionist," November, 1925, p. 3.

[69] "American Projectionist," October, 1925, p. 3.

[70] "American Projectionist," December, 1925, p. 3.

seating 137,000 people. The Bronx had 71, seating 76,740 people. Queens with 67 seated 55,000. From unofficial figures for 1925, there are 7 less theatres in New York City, but the seating capacity has increased nearly 4 per cent.

Stereoscopic Pictures

Stereoscopic motion pictures continue to attract a considerable number of inventors.[71] A large number of American as well as foreign patenst have been taken out for variations of the method of placing the right and left hand pictures in alternation on the film, using either one or two optical systems. Persistence of vision is a principle usually employed.

Studio Lighting and Effects

Considerable development has been made in methods of obtaining the desired effects of distance and size within the studio by the use of miniatures. The Schuefftan process[72] uses a system of reflectors and fixed and sliding mirrors and makes possible the photography of many types of double exposure work in one operation. Even fog, mist, and clouds need no longer be photographed in their natural settings[73] because they too may be imitated by heavy vapors and artificial refrigeration. German film producers[74] are very partial towards the use of miniatures. They frequently use a development which is known as the "perspective construction" in which an intentional distortion of the perspective is introduced, giving an impression of enormous space and size within a limited area.

A new West Coast studio[75] of one of the largest film producers possesses perhaps the largest stage in the world. In the lighting system which is a feature of this new stage all of the lamps used on all of the sets will be operated from overhead, which does away with all cables and connecting blocks on the floor of the studio. The lamps are carried on overhead runways and will be operated by remote control switches from the panels on the main floor.

[71] French patent No. 589513; United States patent No. 1547299; United States patent No. 1560437; and United States patent No. 1548582.

[72] "Motion Picture News," November 21, 1925, p. 2435.

[73] "Scientific American," August, 1925, 133, p. 98.

[74] "Motion Picture News," September 26, 1925, 32, p. 1473.

[75] "Moving Picture World," April 17, 1926, p. 547.

A German firm[76] has produced a motion picture film in which the action is entirely in silhouette.

A writer[77] in a German publication advances the belief that the electric incandescent lamp will ultimately replace the mercury vapor lamp and in conjunction with arc lamps will make possible more artistic lighting results.

Talking Pictures

A number of patents have been taken out for talking motion pictures. The general trend of development appears to be towards either synchronizing a phonograph record which in turn reproduces through a loud speaker with the action on the film or by the use of a sound record placed along the edge of the film outside of the perforations. A Swiss invention[78] consists of a loud speaker operated through an amplifying circuit. A beam of light is controlled by a voice record placed along the edge of the film.

Television

The possibility of broadcasting motion pictures is now causing the producers of motion pictures to ask for further copyright protection.[79] Recent developments in the transmission of pictures by radio is causing some alarm among a number of motion picture producers who are afraid that their right to certain subjects does not cover the transmission of these pictures by radio. The present legislation before Congress on the control of radio wave-lengths makes no mention of the transmission of motion pictures.

The transmission of pictures by wire and radio will undoubtedly receive a considerable impetus following the development of an extremely sensitive photo-electric cell.[80] This cell is described as being very rapid in its action and sensitive to the slightest variations of light. A youthful British inventor[81] claims to have produced a machine which makes possible the distinct reproduction of the sender's face, whereas almost all of the American developments simply transmit shadow images.

[76] "Film Technik," August 15, 1926, 1, p. 96.
[77] "Kinotechnik," August 25, 1925, 7, p. 391.
[78] "Kinematographic Weekly," July 30, 1925, 101, p. 84.
[79] "Cleveland News," February 24, 1926.
[80] Scientific American, March, 1926, p. 162.
[81] Scientific American, March, 1926, p. 163.

The Germans have developed a process of making steel so thin[82] that it is practically transparent. It is reported that this invention is of a great benefit in the development of telephotography and television.

Visual Education

Considerable experimental work is being conducted to determine the relative efficiency of motion pictures as a means of instruction,[83] particularly to supplement oral teaching. The results have, in general, indicated that with many subjects motion pictures may materially reduce the time of instruction without loss in results. One of our members[84] has presented data showing the use of motion pictures for instructional purposes.

[82] "American Projectionist," November, 1925, p. 3.
[83] "Educational Screen," November, 1925, 4, p. 520.
[84] "Transactions," S. M. P. E., March, 1926, p. 66.

THE JENKINS CHRONOTEINE CAMERA FOR HIGH SPEED MOTION STUDIES

C. Francis Jenkins*

THE purpose of this camera is the study of high speed motions—the flight of birds, the movement of animals, the muscular activity of athletes, mechanical motions, etc.

The normal rate of exposures is 3200 pictures per second on standard motion picture film negative. (Speeds greater or less than this are within the range of the camera). Projection of these pictures at normal rate (16 per second) makes the action two hundred times slower than the original movement and twenty times slower than the slow motion films frequently shown in picture theatres. It photographs successfully objects which the intermittent film camera can not photograph at all for purposes of study.

It is frankly admitted that this speed seems incredible, for it means at the rate referred to (3200 per second) that two hundred feet of film pass through the camera in one second. But that is exactly what happens. And at that speed sixteen pictures or frames are put on every foot of the film with such exactness that magnified by projection on a motion picture screen the pictures are not jumpy.

I have been trying for thirty years to acceptably build this camera (it was patented in 1894) but until within the last few months had not succeeded. The instruments are now made with the assurance that each of them will perform with precision, high speed, and excellent picture quality.

Many and varied problems were encountered in the design and construction of this camera as will readily be guessed, because the speed contemplated made worthless the structural practice of the regular motion picture camera. Instead of intermittent movement, continuous movement of the film must obviously be employed. So the camera was built with a plurality of lenses moving exactly in synchronism with the film as the lenses pass in succession across the stationary shutter-opening in the camera front.

The lenses are carried in a lens disc. The lens disc finally adopted is about 13 inches in diameter and contains forty-eight matched

*Jenkins Laboratories, Washington, D. C.

lenses. The lenses are set in lens-pockets in the periphery of the disc, accurately spaced, and all at exactly the same radial distance (see Figs. 1, 2, and 3). This lens disc must be light in weight, so that it may have a quick pick-up and yet be strong enough for safe use at high revolution speeds. An alloy was finally found which acceptably met all requirements. This alloy disc weights but 60 per cent as much as a disc of aluminum, although it machines like the softest gray cast iron and "stays put" when finished, needing no aging or seasoning before or after.

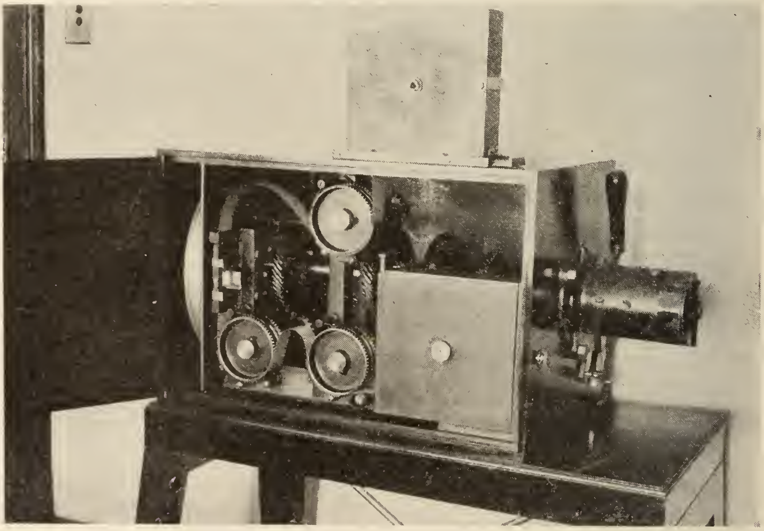

Fig. 1. The Jenkins Chronotéine Camera, open to show mechanism.

The spacing of the lens pockets was far more difficult to attain practically than was at first anticipated but was finally attained by the use of a dividing-head of our own make.

The finished lens disc is mounted to rotate inside the camera casing, so that the lenses cross closely adjacent to a fixed shutter opening in the front wall of the casing.

The passage of the film across the exposure aperture in the plane of the focus of the lenses in what is usually referred to as the tension plate was also a difficult problem, for when a tension was employed, even the lightest tension, the film would catch fire from the friction. The solution was found when air alone was employed to keep the film within safe temperature limits while still holding the film perfectly flat in the exact focus of the lenses.

But of all the problems encountered, by far the most difficult was matching the lenses, which any photographer who has tried to

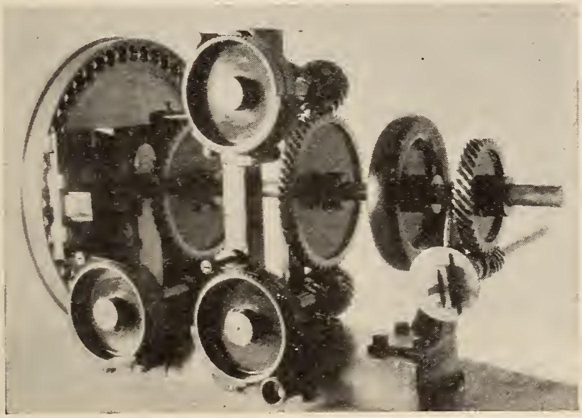

FIG. 2. The Chronoteine camera showing film-sprocket side of mechanism.

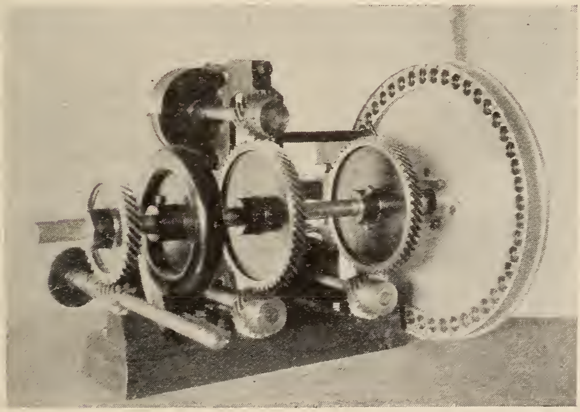

FIG. 3 The Chronoteine camera-rear view of mechanism

match even two lenses will recognize. The lenses first employed were B&L Zeiss Tessar F 3.5 lenses of 2″ focus. They were bought for matched lenses but were not perfectly matched, being only "commercially-matched," as was explained to us later. Anyhow, as nothing short of scientifically-matched lenses were permissible in our work, we set about matching these lenses. I will not trouble you with the details of months of tedious effort; it is enough to say that these lenses are now so accurately matched when fastened in the disc that in the test room each of them coming in succession into position projects a spot of light so accurately as to fall on exactly the same place forty feet away. The aperture in the gold-leaf mask in the focus of the lens that projected makes this spot is so small that it can not be seen when held between the eye and a strong light.

In the camera the lens disc is mounted on one end of a steel shaft upon the other end of which, on the outside of the box, a four-horse power, series-wound, six-volt motor is mounted to rotate it.

One of the mysteries of this camera is the exposure time. To the intermittent camera operator it seems inconceivable that we can get exposure enough at these high speeds with only the super-speed negative film of commerce. The explanation is that whereas for sharpness on the same moving object an intermittently moved film can have at most not over five per cent exposure, with rotary lenses and constantly moving film we get easily more than one hundred and fifty per cent exposure, more than twenty-five times the exposure possible with an intermittent film camera. This sounds like another paradox but the explanation is in the fact that adjacent lenses overlap in time in their successive exposures.

While this camera is very simple, and almost any one can learn to use it successfully, best results come after a certain technique has been acquired. To illustrate, in photographing the flight of a big gun shell, the camera is started first, and then the firing contact of the gun is pressed; whereas, in photographing athletic turns, the athlete is started first, and then the switch on the camera motor is closed. If the camera were started first, the athlete might not get away before the film ran out. However, in either event, the camera man can not change his mind effectively after he presses the trigger.

The timing of the exposure rate, where this is required, may be attained in several ways:

1. We have a 20 inch dial clock which we set up in the picture to be photographed with the main subject. The hand sweeps over the dial at a rate of fifty revolutions per second. As the hand moves almost one-sixtieth of the circumference for each exposure, the time divisions are fairly easily read in the photograph.

2. In another method a tuning fork of five hundred beats per second reflects light from a tiny mirror mounted on the fork and is photographed as a wavy line or dots on the film. The latter is the easier to read, for the wavy line has peaks only every three inches or so, and these are hard to exactly locate. The spots are, however, almost sharp.

3. A high speed gas lamp may also be photographed on the film at any speed desired—a hundred thousand a second if required. This method records very fine time divisions.

4. The scheme we most frequently employ is simply to count the revolutions of the lens-disc-motor shaft with any good revolution counter and multiply by forty eight, the number of lenses passing the aperture each revolution. That is, with twelve volts on the six-volt 4 H.P. motor, a speed of 4000 r.p.m. is attained in about half a second and then held for the one and three-quarter seconds necessary to get four hundred feet of film through the camera in two seconds and record sixty-four hundred exposures thereon in the two seconds or exactly three thousand two hundred exposures per second.

It may be of passing interest as visual evidence of the high speed of this camera to note that two hundred feet of film can be shot up into the air with this camera, the last end of the film being still high up in the air before the leading end of it falls to the ground.

The gears which drive the film sprockets are half-inch face, cut-steel gears. All the bearings are bronze. The 6-volt motor is driven by one or two or three six-volt storage-batteries, usually two. The camera is consequently easily portable for field work beyond the reach of house current and for mobile use. It weighs complete only about seventy-five pounds and is readily divided into smaller, lighter pieces, easily handled by two men for moving it from place to place.

The camera is loaded in daylight with film boxes previously loaded with film in a dark room or at night. Eastman super-speed negative standard stock is used. Prints from these negatives can be made in any film laboratory and projected in any theatre or other standard machine.

The camera can be focused for short distances, but without adjustment any object beyond 20 feet is in sharp focus. The field of vision has a width equal to half the distance from the camera to the object.

Sunshine is adequate for illumination. If artificial light is employed, it should be equal to sunshine.

The camera is fitted with its own (detachable) support of approximately fixed elevation but can be adjustably inclined.

Aside from the economy of this quick method of motion study, a record is kept which can be examined over and over again and by which, as has already happened, new and unsuspected phenomena may be discovered.

The cost of the camera is not so great as one might expect and is mostly in the lens disc but at any price the camera is economic if it solves costly problems quickly.

It is an instrument unequaled for the study of many problems in science and engineering, some of which are not possible of accurate determination in any other way.

Some additional applications of this instrument which immediately suggest themselves are a study of gun recoil, shell trajectories and plate impacts, airplane propellers and landing gear action, bursting of balloons, air hose, pneumatic tire action, water streams, propagation of flame, motor valve action, cam roller jumping, crankshaft whip, shuttle thread knots and bobbin action, brake-shoe and draft-gear application; in fact, anything at all that moves too fast for the eye to follow can be slowed down and examined in detail and at leisure.

THE PUBLIX THEATRE MANAGERS SCHOOL

John F. Barry*

IT IS the purpose of this paper to outline those facts concerning the organization and procedure of the Publix Theatre Managers Training School which will be of interest to the members of the Society of Motion Picture Engineers.

Generous tribute should be paid those members of your Society whose interest and co-operation helped to strengthen certain critical parts in the course of training given at the school. It is these very subjects which I find are given most attention by your society. I mean "Projection" and "Theatre and Stage Lighting". The Managers School is particularly indebted to Mr. Earl Denison, Mr. M. W. Palmer, and Mr. Trevor Faulkner of the Famous Players-Lasky Corporation, Mr. Powell, Mr. Kroesen, Mr. Summers, Mr. Turner, and other executives of the Edison Lighting Institute, Mr. Griffin, Mr. McGuire, and executives of the International Projector Corporation, Mr. George C. Edwards, Editor of the American Projectionist,—all members of the Society of Motion Picture Engineers, to whom graduates of the Publix Theatre Managers Training will make evident their appreciation by the way they live up to the standards of your Society and the ideals of the industry during their after careers.

It would be well at this time to correct a false impression concerning the Managers School which was brought to my attention by some of your members. The impression exists in certain quarters that, because the school in its schedule has arranged so detailed a course in projection, one of its purposes is to graduate projectionists. It cannot be too emphatically insisted that the Managers School does not and will not train projectionists. Its one object is to give training in motion picture theatre management. However, supervision of a theatre manager cannot be completely effective in any theatre unless the manager understands the general principles of projection, and has an understanding, appreciation, and sympathy for the very important work done by the expert or experts in the cine booth.

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motion picture theatre buildings and the up to date equipment and renovation of motion picture theatres. It requires no prophetic vision to see what the next ten years will bring in the way of further development.

But more important than perfect equipment and powerful finance is good management. This good management will always be searching for wiser and better methods. Its power of creation will continue to replace bad practices with good by applying a professional knowledge of improved methods.

Management that can do this must be trained for this responsibility. Such training is not new in other American businesses. I have studied particularly the training given by the Standard Oil Company, the Curtis Publishing Company, the National Cash Register Company, the Westinghouse Electric Company, and others. Only recently I sat in conference with representatives of the National Hotel Association who have come to realize that there must be very definite training for hotel managers.

Now, the idea of training for motion picture theatre management can be disparaged by those who state "Showmen are born and not made." Like so many other sayings that have been strengthened by repetition, this does seem true on the surface. In fact, it may be altogether true that the master showman, the eccentric genius, has a gift direct from God, and nobody on God's earth can implant that gift where it does not exist. Training that would attempt to develop such would be impractical. However, almost every man has a certain sense of what can be called showmanship. This basic sense *can* be developed by practical training. But the more important thing to realize is that efficient theatre management is a *business* profession. In any business, management is efficient that can direct and supervise activities so that the main objective is more completely realized. The theatre manager is a better manager the more he can save dollars of needless expense and the more widely he can develop the permanent habit of theatre attendance among an increasingly greater number of potential patrons in his community. This requires good, sound, professional business sense. It is that which the Managers School aims to develop. It does not attempt to develop a group of theoretical or, least of all, eccentric showmen.

Realizing this, you can understand the purpose of the Publix Theatre Managers Training School, which is set down clearly in the foreword of the catalog of the school:

One of the most highly developed branches of the motion picture industry is the operation of about fifteen thousand motion picture theatres in America and thousands of others throughout the world. Many of these theatres, to whose beauty all the arts have contributed, are ranked among the most imposing structures of the community. They operate with the precision of great railroad terminals and with the courtesy known in the best hotels. They serve a clientele among which are numbered the best people of every community. The development of motion picture theatre operation must continue to keep pace with that of the industry.

Although motion picture theatre management is a highly technical work which requires especially trained experts, until the establishment of the Publix Theatre Managers Training School (formerly the Paramount Theatre Managers Training School) there was no training center for those preparing to carry on this important work. Men developed at different points throughout the country by the sheer force of individual efforts and experience. The evitable result was much waste, much blundering, and a general failure to capitalize on the individual advances of this highly technical profession. Moreover, there was no reliable source from which to supply the trained men needed to fill the vacancies.

The problem of entertaining the public, week in and week out, in different parts of the nation is a big one. Because entertainment depends so much upon individuality and personal initiative, the operation of theatres cannot be mechanically standardized. However, for successful theatre operation there are certain basic principles. Trained in these principles, theatre managers of the future will have a big advantage, and in this training, intensive study of what the leading managers of the country have done and are doing will give a fund of useful information.

The Publix Theatre Managers Training School will not only prove a benefit to the industry but offers a chosen vocation in which ambitious young Americans can enter a career of service with excellent opportunity for good financial returns.

The purpose of the School is essentially practical, and its scope most comprehensive. It gives intensive training in every detail of theatre management, explaining not only the "How" but the "Why." It will lay a solid foundation for the future by sending out ambitious graduates equipped to carry on an important work. This School should help to establish a high standard for the profession, for students are trained not only in practical details but also in the responsibilities of civic duties and in the high obligations to the ideals of the industry. All this should be an influence affecting the dignity of the motion picture theatre. Because these theatres are everywhere contributing to the welfare of their communities, it cannot be denied that there is a certain dignity and importance in the profession of theatre management. It makes a just claim on the professional spirit and is governed by the ideals of American business. Graduates of this School go forth with a realization of the significance of the work they undertake and of its possibilities for service.

The first session of the Managers School commenced in September 1925 and closed in February 1926. The second class, which started training in February of this year, is now in session and its training will continue until August.

Before the opening of the first session the catalog of the school was distributed throughout the country by mailing to colleges, graduate schools, and business colleges. It was distributed also by the managers of theatres and exchanges to those men in respective communities who would be interested. The result was that about five hundred applications were received. They came from every state, and from Canada and Mexico. (Applications have since come from abroad). The applicants represented many professions—lawyers, doctors, mining engineers, West Point graduates, interior decorators, advertisers, salesmen of varied commodities, theatre organists, projectionists, motion picture engineers (there is a member of your Society in the present class), and *theatre managers* who realized that although they had had practical experience, they could profit by the training that was given. The selection of men was determined by such factors as education, experience, intelligence, physique, personality, a general aptitude for the profession of theatre management, and the firm desire to make it a career.

Training is given over a period of six months. There is formal instruction in the theatre-auditorium of the school. The schedule includes about seven hundred hours of this formal instruction, which is given by close to two hundred experts whose long experience has given them a practical knowledge of what not to attempt, what to do, how to do it, when to do it, and how to do it economically. Besides, there is field survey work. According to a very detailed schedule, the men enrolled visit the different theatres in the vicinity of New York—theatres of every type—to study and analyze operation. This field work is not haphazard but in each case deals with specific and clearly defined problems. When the class has mastered certain principles, they are assigned to different departments at local theatres to assist in the preparation and execution of the daily routine.

Some one has said that the activities of the efficient theatre manager include activities not only of other closely affiliated businesses but also of others which at first thought do not seem to have any bearing on theatre operation. This is evident from the course of training followed, which includes The History of the Motion Picture; The Development of Production, Distribution and Exhibition; The Theatre Map of the United States; Types of Theatres; Economies

Which Justify Circuits; The Inter-relation of Production, Distribution and Exhibition; The Factors Which Determine the Selection of Theatre Sites; Ventilation; Fireproofing; Maintenance of Equipment; Contact with the Community; House Service; Orchestra and Organ Music; Projection; Theatre and Stage Lighting; Presentations; Prologues; Exploitation; The Principles of Motion Picture Theatre Advertising; Mechanics of Newspaper Advertising; Outdoor Advertising; Window Display; The Preparation of Newspaper Advertising and News Stories; Publicity; Tie-Up with National Campaigns; Children's Matinees; Holiday Programs; Psychology of Entertainment; Principles of Business Management; Effective Expression; Program Building; Theatre Insurance; Accident and Fire Prevention; and Theatre Accounting. No attempt was made here to list completely the subjects in which training is given but rather to show that the fact is realized that the activities of the capable theatre manager are varied.

It will take some time for the results of such training to be felt, because those who complete the training at the school do so with the realization that their training has only started; that it will take long experience to round it off. So this is no time to make any statement concerning the results of the Managers School. In the meantime, as we watch developments in the Motion picture industry, we can realize that the place for the most striking development during the coming years, which will bring an increasingly greater percentage of the American public to a greater love for motion picture entertainment, will not be in production or in distribution. For they have reached a standard which leaves less room for improvement. The most striking improvement will be in motion picture theatre operation.

DISCUSSION

Mr. Hill: I think we are indebted to Mr. Barry for telling us about this School. It is a distinct step in the right direction. Viewing it from an engineering standpoint, I think it will give us an outlet for our efforts that has been lacking. The theatre manager must be the one to pass final judgement on new developments. Heretofore, being untrained in the fundamentals of his equipment, he has had to rely largely on the supply dealer, who in turn was seldom in a position to furnish unbiased recommendations. Forming as it does a nucleus of theatre managers trained in the engineering field, I feel that it will mean a great deal to the Society and will bring a wider appreciation of the work of the Society's members.

I notice that Mr. Barry said it was not time to give definite information as to the success of the school, which is very modest. I don't see how it could be anything but a tremendous success, because it has been gone at in the right way. I hope, however, that the School will succeed in convincing its graduates that they have not cornered the market on projection knowledge.

President Cook: I am sure that the graduates of the school will have been inculcated in the curriculum with the necessity for continuous progress in the science and industry and that they will continue to benefit by everything that follows in the industry. It occurs to me that we should all be very happy if Mr. Barry would include in the items of recommendations to the graduates that they become members of the Society as a necessary adjunct to their managerial duties.

Mr. Barry: I shall do that. I have a realization of the good that will come to these men from the Society.

With regard to what the previous speaker said, a point we emphasize most completely at the school is that in this business the knowledge is never in a closed book. No man knows everything—particularly concerning projection. These men will keep an open mind and do their utmost to keep abreast with what is being done.

President Cook: I was sure that Mr. Hill's apprehension was unfounded, but it is gratifying to have you assure him of it. I was pleased to hear Mr. Hill's earlier remarks of the school because he speaks with authority and experience with the Army school and was able to comment intelligently on the matter.

Mr. Brown: I should like to emphasize one point with regard to the School. The Society need not hesitate in the least to co-operate with the school on any grounds such as this. I recommend that a small committee, possibly three members, be appointed by the Society to remain permanently active until the next meeting for the purpose of considering how the Society may best co-operate with Mr. Barry in placing our engineering specialized knowledge at the disposal of the School and with the additional object of securing members for the Society, not only associate members, from the graduates—active members from the extraordinary corps of technical experts which Mr. Barry has assembled and with which he is in constant, intimate communication. I think you have a field there where you will get fifty active and fifty associate members for the Society in a years' time. They will be of a caliber equal to the present active and associate membership. I think it will solve the problem of expanding the membership along the right line.

President Cook: The Board of Governors will give consideration to your suggestion, Mr. Brown. It is not a matter for the Society as a whole, but we are glad to consider it.

Mr. Richardson: Judging from a personal inspection of thousands of theatres, I do not think the industry has needed any one thing more than it has needed a school for managers of motion picture theatres. To show you the ignorance of some managers which can be classed only as stupidity, I went into a theatre owned and managed by one man. He showed me around with considerable pride. He had good projection equipment, but on either side of the auditorium were eight side-lights about seven feet from the floor, in which were sixteen candle power bulbs with plain frosting over them. They were producing the most terrific glare spots you could imagine. After we had examined the plant we stood looking at the picture, and after a while he asked me what I thought of the place. I said, "It's all right except for one thing—those glare spots." He didn't know what I meant. I asked him to have a boy turn off the lights, and he said it was out of the question. It would ruin the show to turn them out, but finally he had them turned out, and he was astounded at the result.

The problems of projection are not merely projecting the picture but the screen surface must be considered while the greatest problem of all is getting the picture back to the audience in the best possible way.

SCORING A MOTION PICTURE

Victor Wagner*

IT TAKES years to accumulate a fund of musical knowledge before one is able to synchronize the music with the picture. A musician who through ignorance or whim chooses music which burlesques a serious scene commits an offence, he destroys the science and art of musical presentation of motion pictures. One has to have at his command a musical library of a thousand different numbers and a sensitive feeling for their different moods to be able to classify the numbers properly. The well known operatic melodies are not very useful, as they fit only the scene for which they were written and which scene the public visualizes on hearing the music. It is therefore important to consider the key in which each number is written to make a smooth musical bridge from one selection to another. In selecting the most appropriate music, one has to be careful not to anticipate the development of character so as not to stamp immediately the man with the cigarette as a villain; or, when a particularly beautiful girl enters, not to draw too hastily the third line of the triangle. Again, if one sees a man walk into a room wearing a derby and having a cigar in his mouth, one does not play mysterious music at once, because he may not be a detective after all. Not only is a knowledge of high-class music necessary but also a knowledge of most of the popular and national music with their characteristics of practically all the civilized and uncivilized nations.

There is one task laid on the musical director who arranges a musical program of accompaniment for motion pictures which is seldom appreciated. This is the task of making music supply in a measure the spoken word—the missing dialogue—the play on the speaking stage—where this is not provided in action and in subtitles. The musical adapter has thirty, forty, or more scenes instead of a series of three or four acts. This I mention, because it must be remembered that no scene of any great length will maintain the same emotional key throughout. In the spoken play, there is a constant shift of emotional appeal as the incidents of the scene progress. But in the motion picture the play breaks up, not into acts, but into scenes, and scenes so arranged that a much closer sympathy of emo-

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tional suggestion may be obtained scene by scene, than is possible act by act. Thus it is that musical accord with the poetry of action and mood can be made scenically unified, and can really produce a more concise and closely correlated emotional suggestion than any other form of union of music and action. Now, I have said that it is one business of the adapter to make the musical accompaniment supply the motion picture with an important part of what the speaking stage gets from dialogue. I mean that while the picture vividly gives to the eye the story, the characterization can suggest constantly a mood to make the spectator mentally sympathetic. It follows that one preparation which the musical director must make is careful study of the picture, sufficient to bring to him definite and vivid impressions and emotions derived from it; he must himself feel the need of the music which he will later select and arrange.

The appropriateness of selection of motion picture accompaniment depends largely on this preparation. Scenically, the motion picture is a great inspiration; no speaking stage can in completeness, in gorgeous realities, and in generous detail approach the scenic richness of the motion picture. So, the musical director is always under the inspiration of an art kindred to his own. And so adept are good motion picture actors and actresses becoming, that careful observation of their pictured pantomime is all the inspiration needed for an impression that readily suggests music best suited to express it. It is therefore the study of the musical director of the picture with special regard to opportunity to make the music aid in its emotional suggestion of something truly felt and appreciated that counts most for the success of his work.

We speak of accompanying motion pictures with music. Now the accompaniment of song, the expression by means of music of a beautiful idea or of a dramatic idea is a province of art; if the song or the idea or scene or story has strong element of beauty, the art of accompaniment becomes really a king to the poetic art. The poet takes ideas and thoughts and gives them beautiful word forms; the accompanist, given this sort of material to inspire him, can add beauty to his work. Now, turning to motion pictures, the arrangement of a musical accompaniment for pictures in which there is definite mood, a central idea, a real emotional element that is consistent, makes a congenial task for a musician, and in the majority the arranger does find pictures inspirational; he does find opportunity for a musical accompaniment that is really expressive of the appeal which the picture makes.

But there are kinds of motion pictures which present difficulties. Take, for instance, the detective story picture, the adventure story, or the farce comedy. In each story the interest centers in the plot. There may be excitement of emotion in looking at the picture, but the emotion is not in the picture itself. Here the difficult thing is not so much to know what to play as what not to play. Music that strikes any hearer as incongruous will do much to spoil that picture for him. Then, too, the action is rapid, and this causes the change in mood of the onlooker and hearer to be abrupt—too abrupt to be successfully followed in music. The point made is that it is awkward and impracticable to accord intimately with the incidents of such pictures. For instance, picture a scene in which two men are struggling for in a cellar while a dance is going on above them. I suppose for realism we should have a dance orchestra off-stage playing dance music steadily while the regular orchestra plays dramatic music according in mood with the fight. This is an extreme illustration perhaps but one which the motion picture adapter will recognize as within his experience.

The film play is a form of art and is analagous to the ballet in that it necessitates, for its adequate presentation, the synchronization of action with music. Thus, in its right development, we find a new art form in music, the possibilities of which are practically limitless. In film play we see one art-form which is dependent upon another —music—for its completion, and it is still incomplete and imperfect for presentation to the public without its musical counterpart accompanying it, just as is the case in the ballet, where dance and action are synchronized with music to ensure a perfect whole. The time has come when the motion picture theater orchestra is receiving universal recognition as an organization of artists who are working to achieve and maintain a high standard in a distinct art. Many times the question has been brought to me, "How do you synchronize the music with the picture?" When we come to the screening room to work on our next pictures, the most important part from the very start is to make a title sheet, which lists the first few words of each main and subtitle and indicates the beginning of each new reel. These titles are used as milestones in the music score as well as descriptive cues. A piano part or a full orchestral score of each orchestration is filed on shelves in the screening room, classified according to mood, nationality, etc. We have one hundred thirty-five such classifications all the way from "Airplane Music" to "Funeral Music" and from "Wedding Music" to "Happiness Music." The next important move is to find the music best suited to the action and mood of the picture without allowing the music to dominate the play, in which event it would distract the attention of the onlooker from the picture to the music. It is mostly sensitiveness of the adapter which enables him to balance the action on the screen with the music in the orchestra pit. Of especial assistance is the up-to-date motion picture machine which allows the film to run in either direction. If the music which has been selected does not fit the scene, the film may be reversed without taking it from the machine, and another selection tried.

Scoring a good picture is just as fascinating as composing. When a picture is scored, one has the satisfaction of knowing that he will have at least twenty-one orchestral performances the first week which is more than a well known composer of fame can ever expect. It may be interesting to know that no music is furnished with the film. Our library consists of about 15,000 different selections with separate parts for each instrument of our large orchestra. The original orchestration cannot always be used exactly as bought from the publisher. In order to make it of the proper length for a scene, endings or modulations are written which must be technically correct. Many times when we are unable to find a suitable selection, we cover the action with music which is originated in our department for this particular scene. In selecting a musical theme for a leading character, the principal aim is not only to be consistent with the atmosphere or period but to portray and intensify characteristics through music. One morning last week, when we were screening our next week's picture, a young singer entered the screening room just as we had reached a touching scene of Stella Dallas. In the dark silence of the room, interrupted only by the buzz of the projection machine, the singer sat down at the piano and sang a tender melody. The effect was spontaneous; each of us realized what new intensity had been given by the song to the fine acting on the screen.

THE PUBLIC AND MOTION PICTURES

Wm. A. Johnston*

THE SUBJECT I have selected is such a broad and ever changing one that several books might be based upon it—and then more books. In this brief paper I can only refer to some present phases of pictures and their public appeal.

The basic fault in our industry today, so far as the contact between pictures and the public is concerned, is lack of segregation—segregation in the making of product, the distribution of product, and the exhibition of product. As one man tersely expressed the situation to me recently: "We try to sell Fifth Avenue jewelry over on Third Avenue." And, of course, it doesn't work.

For the past ten years almost every producing company has tried to do just what every other producing company was doing. All have gone after the same books, stories, and plays, the same stars, the same directors. The inevitable result, of course, has been that the prices for these materials in picture manufacture—raw materials we may call them—shot skyward and have stayed there. But that wasn't the worst of the situation. The other consequence was that most of our manufacturers have been trying to furnish pretty much the same grade of product to purchasers of varying tastes and pocket-books. That in itself is inadvisable, because some people are quite as keen about calico as others are about silk and this preference is not merely a question of price, either. The manufacture of any kind of merchandise must be geared to fill a certain market. It is not possible to fill several diverse kinds of demand and fill them well and establish thereby trade-mark values. And it also follows that the distributor has got to specialize, too. And as we all know the retailer must and does specialize.

I do not want to give the impression that the industry today is altogether chaotic. I can remember the time when all theatres tried to book the same class of product. Today we have our varying grades of theatres; the super type of the downtown section of the big cities, the large and small types of neighborhood houses, the small rural theatres, etc. Just now there is a movement on foot to establish in the large cities a moderate sized theatre to house long runs at two

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dollar top prices, and these theatres I believe will succeed because there is also a public for this class of theatre. I can also remember when distributors tried to sell long and short features out of the same hand. Today, out of twelve national distributors, two specialize in short subjects. That is progress. And as for production, one company in recent years turned a heavy loss into a profit by going definitely and courageously into a policy of producing pictures for the several thousand smaller houses of the country who want a particular type of picture at a rental price they can afford to pay. It is my contention that this preference on the part of the small town houses is not merely a matter of price but also of product; in other words, they prefer Ailene Ray in a good serial to Gloria Swanson in "Madame Sans Gene" or Fred Thompson in a roughriding romance to Douglas Fairbanks in "The Thief of Bagdad."

Let me briefly refer to a parallel in the publishing business. I happen to be interested in the People's Home Journal, an old established family fiction magazine which goes to a million families in the small towns of the United States. There were never more than three high priced authors whose serials our readers would have cared for, namely, Harold Bell Wright, Gene Stratton Porter and Zane Grey. And we haven't needed even these best sellers. Our readers want good, wholesome romances, peopled by characters and stirred by events they can understand and so live the stories themselves. The author's name is of no consequence. The readers resent literary finish as a pose and an insincerity. And so it is with the small town movie public, that is to say the prevalent type of movie goers. I shall speak of the other kind in a moment.

As I say, classification is going on—and naturally so. Take the older amusement business of vaudeville. Today it is definitely settled in its amusement grades of big time, family time, etc. The family time house may want an occasional big time act but not as a steady diet. The varying audiences are content with their own class of entertainment and, as I say, it isn't purely a matter of price.

There is another point in connection with the small towns of the country—and these towns are important not only because half of our theatres are located there but because this small town public should and does have its say about motion pictures. The small town wants clean pictures. There isn't any question about this fact but I doubt if it is clearly understood. I am inclined to think that producers in general don't know much about the small town. They understand better the big cities. You see, it is with the advent of the motion picture that the small towns have had regular and continuous show places. These folks used to go to the larger centers for theatrical entertainment. Now, the entertainment comes to them. The small town's insistence upon clean pictures is not because its people are better morally than the dwellers in the large cities; in fact, I am inclined to believe that it is the small town visitor in New York who supports, mostly, its shady plays. But it is one thing for the adults to sit among entire strangers in a city playhouse and quite another to take the family along and rub elbows with neighbors in the home town movie theatre. Just as people subscribe to magazines they can place proudly in sight on the library table, so they want movies they can take the young people to see and at the same time be honored themselves by the attendance.

I spoke just a moment ago of the prevalent type of movie goer and inferred that there were other people in each neighborhood who rarely attend the theatre. That is perfectly true, as we all know. They are the kind of people who greatly prefer that acting of "Moana (of the South Seas)" to that of Bebe Daniels, and, of course, pictures should be made for these people if that is commercially possible. There again, however, comes up the same matter of segregation. You cannot sell such different kinds of pictures with the same machinery or at least by the same methods. You are appealing to different customers; so you must reach them in different ways. Mv own opinion is that one of these days the non-theatrical halls of the country—churches, schools, lodges, Y.M.C.A. auditoriums, etc.,—will be served by producers and distributors dealing only in programs especially acceptable to this particular clientele, which is a very large one. And I also believe that this new outlet for motion pictures and this new patronage for them will actually prove a boon to the motion picture theatres by creating new patronage.

I also alluded to vaudeville just a moment ago, and here again we have another new phase of picture theatre entertainment. It is stated that Al Jolson was recently offered a staggering sum and so, I believe, was Nora Bayes and other vaudeville headliners to leave their present circuits for those of the picture houses.

It is rather a curious situation. In the early days of pictures as show attractions they were of such minor consideration in vaudeville houses that they were actually used at the conclusion of the bill to get people out of the theatre. Then, as pictures continued to absorb the public fancy, they crowded vaudeville into a constantly lesser position. Now it would appear that they are using their strength with the public to bring vaudeville back. But I doubt very much if this present leaning toward vaudeville on the picture bill is anything more than a flurry in picture theatre competition. What has happened is this: Picture theatres have grown in seating capacity till today they can, by virtue of their intake, outbid the competing vaudeville house. And now that we have picture theatre circuits, a large group can outbid the vaudeville circuit. It would almost appear as if these new circuits were exulting in their power, like the young bully who wants to grapple some one just to feel his strength, for surely there is no real call today for the joining of picture and vaudeville entertainment.

If the production of pictures were in a decline today that would be one thing. But the contrary is true. Just last week the pictures playing on Broadway, most of them special attractions, almost dominated the amusement section of the Metropolis. Twelve pictures grossed in the week something over $330,000.

If, again, vaudeville were in a great ascendancy that might be another thing. But again the contrary is true. There are so very few big time acts today—and surely the modern picture palace wants nothing else—that they won't begin to suffice. And that means the adding of cheap vaudeville to pictures that have cost a fortune to produce and orchestras that formerly one could hear at only the great opera houses.

The receipts of a picture house change with the appeal of the picture not with that of the added attractions. Last year the Capitol Theatre, New York, had a varying intake running from $30,000 to $77,000 a week. Yet the added attractions—and while not borrowed from the vaudeville ranks, they were excellent—were of about the same calibre throughout the year. It was the picture that made a difference in the receipts of over forty thousand a week—the picture and the usual influences—seasonal or what not that affect all theatre attendance.

But the point is that pictures are one thing and vaudeville another. They don't go together. Pictures and music do. Each enhances the other. Each has a universal and steady appeal. Each has a tremendous following. Each is a universal language. Vaudeville simply doesn't belong in the same category.

Another point in this connection which may well be emphasized is this: Picture producers today must not suffer because of the high prices which will inevitably be paid to vaudeville acts once the big picture circuits start competing for them. I don't hesitate to say that the picture producer today deserves and needs higher picture rentals from the big picture theatres, which can afford to pay and must pay if pictures are to maintain their remarkable progress. Picture production is a highly hazardous enterprise. It is only where it is today because of the millions that have been freely gambled in it; and it might be added that picture theatres are where they are today for largely the same reason. It would be calamitous, for instance, to have Douglas Fairbanks driven out of pictures in order to make room for Al Jolson, the vaudevillian.

Just the other week a serious situation came to my attention. A two reel novelty picture was made in color and brought to New York for distribution. It was expensively made and meritorious in every way. But the booking offered by one of the picture theatre circuits was so low that no more pictures of that calibre and cost can be made except at a heavy loss. This is a far from healthy situation.

Considering the fact that picture plants and theatres now have an investment in them, according to report, of about a billion and a half dollars, that because of the hold of pictures upon the public an industry has been reared that is the marvel of the world today, we had best concentrate upon the advancement of the pictures. What with the advances in color, synchronization of pictures and music, radio, and all the wonderful technical discoveries of this remarkable age, the future is alluring enough.

DISPLAY ENLARGEMENTS FROM SINGLE FRAME MOTION PICTURES*

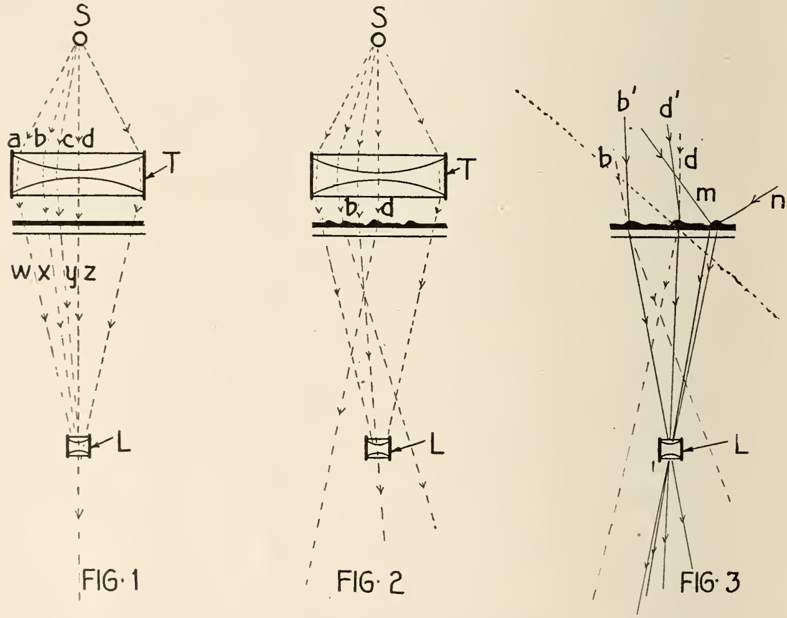
K. C. D. Hickman

A GLASS rod in spite of its transparency is quite visible. The reflections from its surface and interior and the imaging of other objects by refraction make it easy to see. If the rod is lowered into a glass of water, it becomes much less obtrusive and sharply defined; immersed in glycerine, it is practically invisible. Changing the rods environment from air having a refractive index widely different from glass to glycerine with the same index as glass has prevented surface reflection and destroyed the power to deflect a light beam and form images.

The essential portion of a finished motion picture film, the picture, cannot be supported in space but must rest in a stratum of gelatin upon a transparent base. The gelatin and base, surrounded as they are by air of a different refractive index, have a visibility and an individuality of their own. However perfect the base, there must always develop minute irregularities and scratches which scatter or defect the light beam and destroy "quality." In theatre projection, where a number of pictures are superimposed each second, the defects being largely irregular tend to cancel themselves in their effect on the retina. Also, "quality" is subsidiary to "interest" of the film. On the other hand, display enlargements from single frames suffer with every minute defect in the small negative. Particularly unpleasant is the grain pattern found in the half tones of the deposit. Irrespective of care in manufacture, there is a natural and inherent tendency for individual emulsion grains to gather together in clumps, and another possibility is that light exposure may select certain grains in the clump for preferential action. It is still a moot point whether further segregation takes place during processing, but it seems probable that a re-arrangement of grains occur while the gelatin is plastic. The result, however, is that there is a minute but quite definite pattern to the body material of the image. Nothing can be done to kill the pattern, but its effect can be minimized. If one regards a piece of film having a contrasty

* Communication No. 275 from the Research Laboratory of the Eastman Kodak Co.

image or one treated with ferricyanide-hypo reducer, it will be seen that the emulsion side reflects light as perfectly as the base on the parts where there is no deposit. In the region of the image only a diffuse reflection can be obtained, not a scatter due to the silver grains superimposed on the regular reflection of a smooth surface but a complete absence of shininess. This means that the grain clumps, whether by tanning or by the room they occupy, have roughened the surface. The effect of each clump is exaggerated by



FIG·1 FIG·2 FIG·3

Figures 1, 2 & 3 indicate the path of light pencils through "perfect" film, and film which is irregular or scratched, demonstrating the improvement when the condenser is replaced or reinforced by a diffusing screen.

the slight deflection of the beam on its journey from light source or condenser to lens at this point.

The exaggeration and the defects of the film base can be reduced almost to zero by immersing the film in a liquid of the same refractive index or rather the mean index of base and gelatin. Further improvement is effected by using a wide aperture projection lens which concentrates on one layer, the image, and by using a diffused light source. We will deal first with the question of light source.

Consider the perfect negative and condenser system suggested in Fig. 1. Pencils of light proceed from the source *S* in straight lines *a*, *b*, *c*, and *d* to the condenser, where they are uniformly bent to new straight paths *w*, *x*, *y*, *z* to the lens *L*. If, however, the negative is not perfect but is irregular or scratched on the surface some of the light pencils will be deflected from their paths, as in Fig. 2. Because the pencils *b* and *d* do not reach the lens, the points on the negative where their deflection occurs will be projected as dark places. Suppose, now, we substitute for the condenser supplying approximately parallel rays a window of completely diffused light.

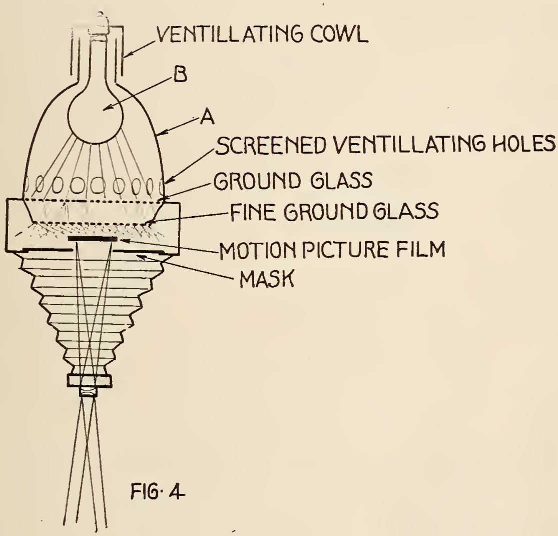


Fig- 4. Diagram of projector designed to minimize imperfections in image and base. Note the large area of diffusing screen and mask isolating a single frame.

Each point on the negative is supplied by rays from an indefinite number of directions; hence, though the pencils *b* and *d* do not reach the lens, *b′* and *d′* and also *m* and *n* which, if the film were not scratched, would pass through in straight lines to be absorbed in the bellows, become bent to pass through the lens. It is obvious, therefore, that the more the light is diffused and the larger the area of the window the better chance there is of rendering the surface inequalities invisible.

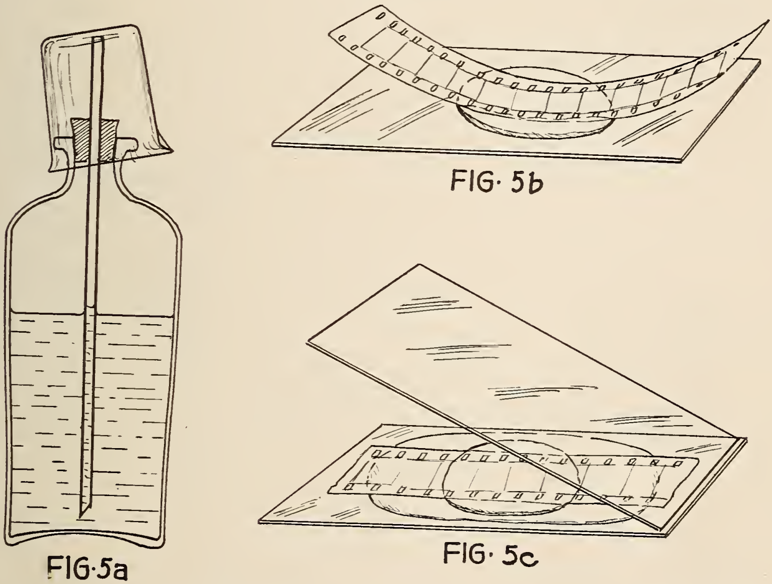
Diffusing screens vary in efficiency. To break up the light from a single lamp completely requires such a dense piece of opal glass that the projection of a single frame to give a 12×10 image on bromide paper necessitates a very long exposure. Fig. 4 suggests a method of obtaining fairly good illumination. A ventilated lamp-house *A* accommodates a 200-watt gas filled lamp *B*. Two inches from the bottom of the tipless bulb a 7×5 sheet of coarse ground glass is secured, and one and a half inch below this a piece of finer and smaller glass. The latter should bring the film to be enlarged as close to the diffuser as practicable. To prevent lens flare from the relatively enormous background degrading the shadows of the picture, a close fitting mask should be placed in or below the carrier, confining the light to the one frame under treatment.

Probably a great many liquids would serve to render the film invisible, but those having a refractive index round about 1.4 to 1.5 with no solvent action on the film are best. A sufficient choice would be:

For dry film	Carbon tetrachloride Benzene Chloroform	for use in cell only
For dry film	Xylol Toluol Turpentine Glycerine	for use in cell or between glass plates
For wet film	Glycerine and water Water	

In the simplest application, the film is sandwiched between two pieces of glass and placed in the enlarging lantern, preferably a vertical projection printer, in which the film may remain horizontal. The sandwiching requires considerable skill. A bottle of pure medicinal glycerine is fitted with a rubber cork and glass tube, Fig. 5A, and kept when not in use covered with a beaker. It is important that the bottle should never be shaken. A clean piece of glass is roughly leveled with a spirit level and a pool of glycerine (perhaps a teaspoonful) poured in the center. There must be not a single air bubble. Onto this pool a strip of three or four selected frames must be lowered slowly and in a convex arc emulsion downwards, Fig. 5B, until all are in contact with the liquid and glass. A second pool is then poured on top of the film and the cover glass lowered into position. This is best done by placing it in contact with one edge and allowing the other end to fall very gradually. The glasses should be considerably bigger than the picture strip, so that plenty of glycerine may be used without it reaching the edges and making a mess of the slide or lantern. Glycerine is chosen as the cementing liquid because it is sufficiently viscous to stay on the glass while mounting and later in the lantern. After use the glasses should be pulled apart, the film wiped, and then put to wash in running water for a quarter of an hour. This washing is the chief drawback to the use of glycerine, which otherwise gives excellent results.

Where many enlargements have to be made, a cell for holding a volatile liquid may be mounted vertically in the carrier slide

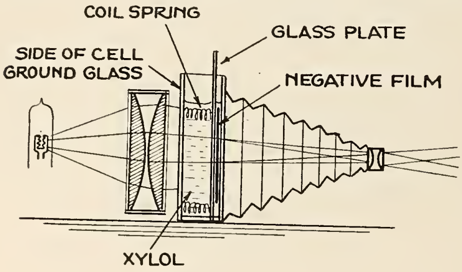


Figs. 5a, 5b, and 5c illustrate method of producing a Glycerine "Sandwich."

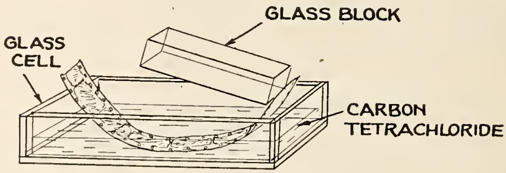
of the older type of horizontal enlarger. Xylol or carbon tetrachloride make excellent fillings. The film is immersed, moved about to detach adherent airbells, and squeezed against one wall by a piece of loose glass and a couple of springs, Fig. 6. After use the film is merely wiped and hung up to dry, a matter of a few seconds over all.

A simple method for really rapid work employs a shallow glass trough and a thick glass block, Fig. 7. The trough is filled with a mobile liquid, the film immersed, and the block lowered at an angle till it squeezes the film flat *without* the intrusion of air bubbles. The trough should be mounted in a wooden drawer which in turn may slide into a square frame located between the lamp house and bellows of an "autofocus" enlarger or projection printer, (Fig. 8). The only danger with such condenserless apparatus lies in overheating, a danger which can be avoided by having the lamp lit merely for arranging the picture and during exposure.

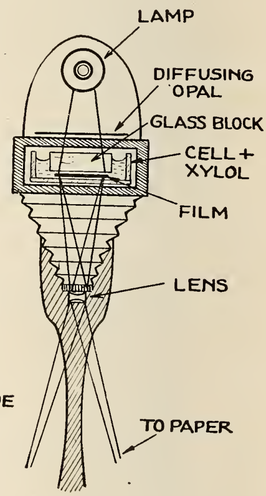
A useful variation if used with caution is the enlargement from wet film. The refractive index of wet gelatin is so near that of water



FIG· 6



FIG· 7



FIG· 8

Figure 6 suggests conventional enlarger adapted to take trough of Xylol in place of negative carrier. In Figs. 7 and 8 the same idea is applied to the vertical projection printer, using a glass block to eliminate the top surface of liquid.

that merely sandwiching the film between glasses under water, wiping the outside of the glass dry, and placing in the lantern will give excellent results. The water should contain at least 1% of formalin and should be in contact with the film for some minutes before subjecting to the heat of the lantern. The wet immersion does not take care so well of the base side of the film, but if the procedure is reserved for samples direct from processing machinery (i. e., before drying), there should be no trouble from scratches or handling marks.

Besides varying the optical arrangements there are additional schemes for improving quality. In scenes where there is little movement, the images in one or two chosen succeeding frames may happen to be identical, though the purely haphazard scratches and grain patterns differ. If a number of frames are focused in turn for a fractional time over the bromide paper, a composite picture is built up which develops with improved appearance. The method is tedious and demands the use of a special projector and pull down mechanism.

Another device consists in throwing the image very slightly out of focus. At the great magnifications employed the outlines of the picture are already a little diffuse, and the addition of a further trifle is hardly noticeable. The grain pattern, however, is reduced from obtrusive sharpness to a less objectionable mottling. A similar effect may be secured in quite a different way. A layer of bolting silk or a photo mechanical half-tone screen may be interposed between lens and paper at a distance from the latter varying from actual contact to two inches away. This imposes a regular mosaic, reminiscent of coarse canvas, on the picture which while destroying little of the detail renders defects in quality less objectionable.

Yet another variation consists in moving the film relatively to the paper during enlargement. This can be done by shaking the enlarger or attaching an electric bell to the lens panel. The advantages, however, are doubtful.

In conclusion, it may be stated that contrary to general opinion the most pleasing result for display purposes can be secured by using a contrasty glossy paper. This gives the picture such snap and brilliance that the lack of quality becomes subsidiary. The heavy surface matte papers, while burying many defects, do not throw the subject into sufficient relief.

There may be those who doubt the utility of such elaborate precautions for securing single frame enlargements. Most of the advertising material in the motion picture business is admittedly artist drawn or made from "still" negatives. The necessity for the latter, however, lies in the appalling quality of the single frame enlargement. There is no doubt that for subject matter and action the picked single frame must be superior to the posed still. It is hoped that this short paper will induce at least some of those whose business lies this way to try the experiment of making two enlargements from motion picture film, one "straight" and the other using the "glycerine sandwich" in conjunction with diffused lighting.

DISCUSSION

Mr. Palmer: I presume these enlargements were made from the original negatives and that they were photographed on negative stock to begin with.

Mr. Capstaff: I wish to modify a statement that Dr. Hickman made. I never contemplated using the immersion method of getting rid of scratches for the projector. I planned to use the method on a projection printer in duplicate negative making where we had to work with badly scratched original negatives. I finally abandoned the whole thing as impractical and went over to diffused light.

Mr. Norling: I wonder if you have conducted any experiments on superimposing the images on adjacent frames, where the action is slow enough and where there is no overlap of motion.

Mr. Crabtree: Does the glycerine produce a better effect than varnishing the film on both sides with a varnish of suitable refractive index?

Mr. Davidson: I am wondering if experiments were made with slightly out of focus effects. We used to get surprising results in this way with old scratched negatives.

Mr. Gregory: I should like to know the focal length of the objective used in making these enlargements.

Dr. Hickman: The negatives are on negative stock, some having been taken in the laboratory and others submitted as samples by various film laboratories throughout America. I might add that only in one example shown was the scratch produced by emery; the rest are genuine projection markings.

To Mr. Capstaff, there is, of course, no answer; I wished to show that I was not the only one thinking along these lines.

To Mr. Norling, the written paper goes into the question of graininess, superimposed images, diffusing media, and so forth, but owing to the time being short I did not want to go into that. In the examples passed round, there was no superimposing of one picture on the other. Certainly that method can be used to diminish graininess if there is no motion to the subject.

The objection to varnish is that on the most carefully hand varnished picture you will find at the end of the operation the same fluffmarks; and the film is not immediately ready for use. It takes little longer to use glycerine than it takes to load the slide in any other way. The number of varnishes which do not contract on drying are limited; I don't know of any, as a matter of fact, which will not reproduce the scratches on drying down.

The out of focus effect will be noted as lacking in some of the enlargements, these being critically sharp. I agree with Mr. Gregory that putting the picture out of focus does diminish graininess without appreciably affecting the definition of the image. In connection with this work, I should like to point out that the procedure gives a very real effect. The improvement is most marked when small negatives on high speed film are to be enlarged—I have used the method for years for amateur snapshots taken with a small camera. With motion picture film the grain is already reduced to the smallest consistent with speed, and the alteration with glycerine is not so marked. There is a very real gain in quality however, if all the precautions mentioned are taken.

In answer to Mr. Davidson, the projection lens was about 7″ focus.

SOME DEVELOPMENTS IN THE PRODUCTION OF ANIMATED DRAWINGS

J. A. Norling and J. F. Leventhal

THE ANIMATED cartoon was the first form of motion pictures. The early devices which served to create the illusion of motion consisted of a series of drawings made of individual phases in a cycle of motion. The cycle of motion might be a complete step of a running horse. If some means is provided of viewing these individual drawings one after the other at the proper speed, the object will be seen to move.

The Zoetrope, described in 1831, was an instrument which established the illusion of movement in a series of drawings. This device is shown in Fig. 1. The Zoetrope was revolved, and the pictures were viewed through the slits between pictures. Similar devices have been used from the time of the Romans, so the basic idea is not so very recent.

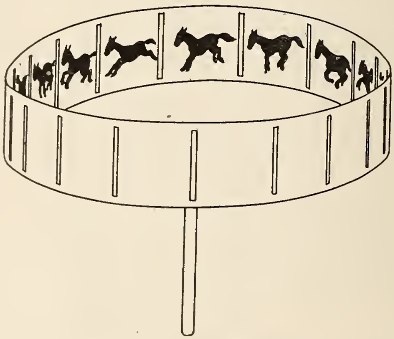


Fig. 1. The Zoetrope.

Development of the motion picture camera provided a means of photographing actions, and study of motion became simplified. The animated cartoon appeared early in the history of motion pictures but did not become commercially practical until the basic methods now in common use had been developed. The method used in the production of present day cartoons consists in placing the action upon transparent sheets of celluloid or gelatin. These are laid over a suitable background and photographed in the proper order upon motion picture film. First the background is laid out, the general action of the characters being confined thereupon within specified limits. The movements of the cartoon character are animated in pencil on white paper, being confined within the limits established by the background. The pencil drawings are then traced in ink upon thin sheets of celluloid and the back of the celluloid

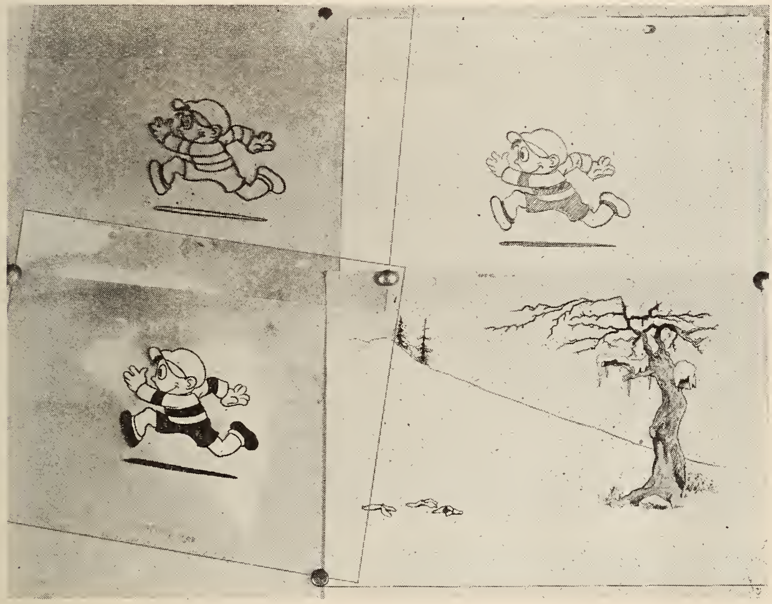


Fig. 2. Showing the penciled animation, the celluloid tracing, and the background upon which the transparency is laid.

behind the drawing is painted with an opaque water color of suitable shade. This idea of opaquing the back of the transparency, simple as it is, is the key to the use of celluloids. It is the one thing that makes possible their use, thus enormously reducing the labor incidental to cartoon production. When this idea was put into practice, the artist's work was reduced about three-fourths. The celluloid, containing the picture of the cartoon character, is laid upon the background and the composite photographed on motion picture film. A means of registry must be provided to keep the drawings in the proper place. For this purpose two holes are punched at the top of the background and celluloid, into which pegs are fitted.

The penciled animation is shown in Fig 2, which also shows the background upon which the transparency is laid. There are many short cuts in production that reduce the amount of labor connected with the tedious work of making an animated cartoon, and one that will be obvious is that several transparencies may be laid over the same background at the same time. This makes possible the common practice of drawing the stationary parts of the body of the character upon one celluloid and the moving parts of the body upon another. In Fig. 3 are shown the elements of a figure dis-

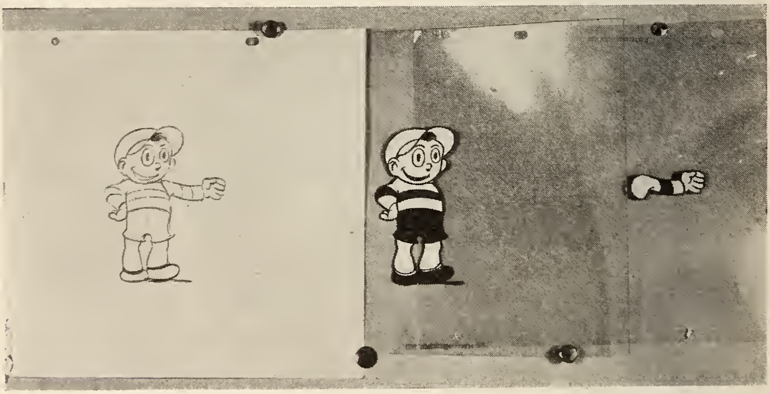


Fig. 3. Showing moving part (arm) drawn on a separate celluloid.

membered in this way. Thus, it becomes necessary to draw only the actions of the arm upon one set of celluloids, using another celluloid containing any phase of the complete cycle of arm motion. The application of animation to comedy is limited only by the artist's imagination and his sense of humor. Some of the current animated cartoons deserve a high place in any motion picture program.

There are many interesting things to tell about animated cartoons that cannot be touched upon in one brief paper. The application of the principles of animation have made possible the production of animated technical drawings. This form of motion picture has become of increasing value to every branch of industry and science. In the educational field, it is probably the most valuable of any form of motion pictures, by its use can be described and shown the most intricate mechanical actions. The operation of machinery can be shown as by no other means. Drawings of interiors of blast furnaces, steam engines, flow of electric current, the operation of the vacuum tube, astronomical theories, Einstein's theory and hundreds of other things screened from human eyes and the understanding of most humans have been depicted in animation. During

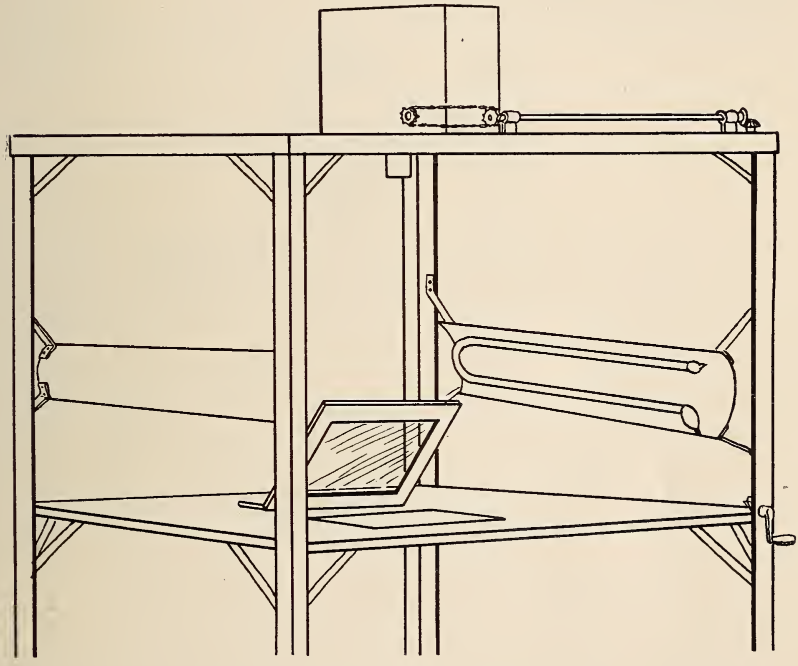


Fig. 4. An early type of cartoon stand.

the world war many "Training of the Soldier" films contained animated diagrams of such things as troop movements, sectional views of the machine gun, trench mortar, shrapnel head, fuse caps, bomb sights, etc. The United States Navy used a film on the marine gas engine to shorten the period of instruction when the steam launch was replaced by gasoline launches after the war. Many improvements and developments to increase efficiency of production and effectiveness of presentation have been made.

Fig. 4 shows an early type of cartoon stand. Fig. 5 shows one of the latest installations operated by mechanical means and adjustable for various sizes of drawings, whereas the field and the camera in the old stand were fixed. This stand is equipped with an automatic focusing device, automatic actuating mechanism for moving the film, automatic dissolving shutter, mechanical sliding panoram, and a number of other things. All contribute to the efficiency of the device and make possible startling effects impossible to achieve on the older and simpler installations.

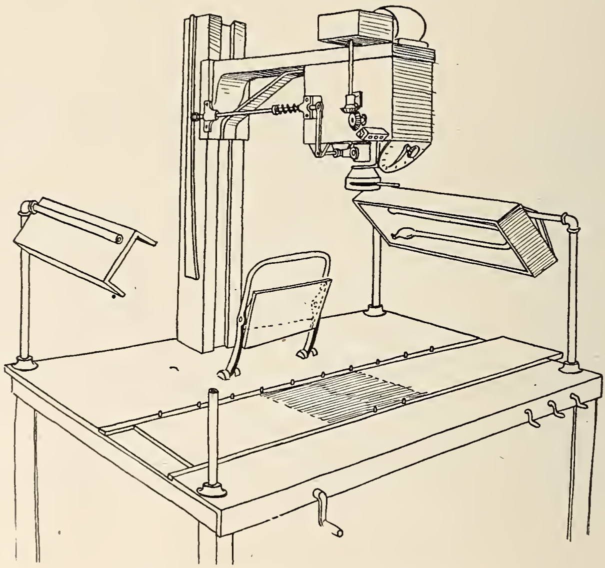


Fig. 5. Modern cartoon stand.

One of the most interesting of recent developments is the combination of cartoon and straight photography. The three methods in most common use are double printing, double exposure, and the making of enlargements from the film. In double printing two sets of drawings of each action must be made and registered accurately. These drawings are animated on white paper upon which is thrown an image of the regular photography motion picture with which it is desired to combine the animated cartoon character. The device for projection and tracing is shown in Fig 6. The image is projected down upon the paper, and the drawings are made to fit with the action of the straight photography characters. Two negatives are made of the cartoon and double printed to secure the desired effect.

The second method consists of photographing a projection from a print of the photographed actions with which combination is desired. A device for doing this is shown in Fig. 7. The image is projected up and through a transparent screen. There is no illumination except from the projector, of course. The celluloid containing the drawing is used for a mask, and the projected image is photographed by the camera above. The resulting negative, if developed at this stage, would leave a blank space where the drawing had masked off part of the projected image. The negative, however, is wound

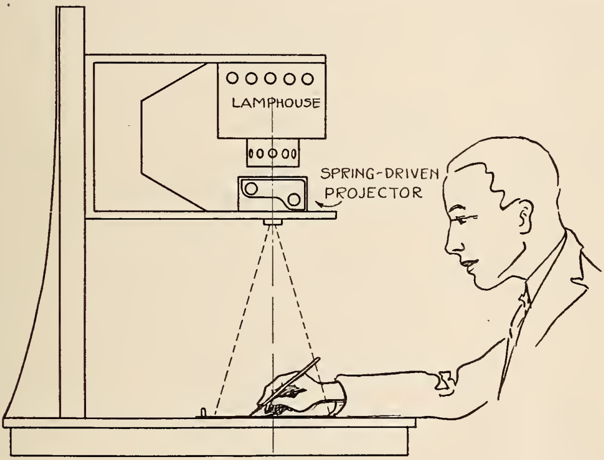


Fig. 6. Device for tracing projected motion pictures.

back in the camera, and another exposure is made. This time the lights are turned on, a black card inserted under the celluloids that carry the drawings, and an exposure made. Only the cartoon character is exposed in the place left blank by the mask in the first exposure; the background being black reflects very little light back to the film, and the exposure from the black card is slight. The negative resulting from these two manipulations thus contains the combined actions of cartoon characters and real characters. The quality of the print is often very good except for a slight graininess, which, however, is not quite as pronounced as the graininess in a duped print.

The third method simplifies the work for the artist. In this method, enlargements are made from a straight photography negative, upon which he can work directly. It would seem at first thought that enlargements made from each frame of the negative would be prohibitive in cost, but by merely applying some well known principles of quantity production, this cost can be kept within reasonable limits.

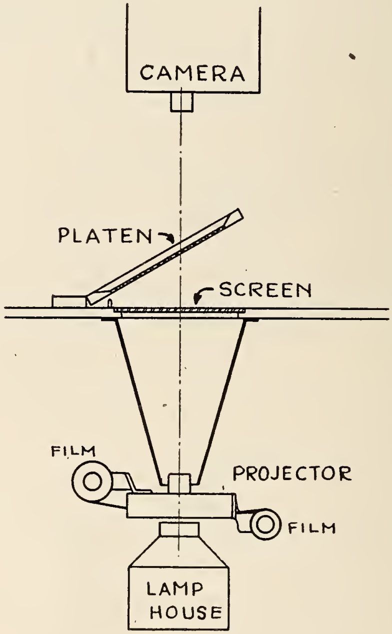


Fig. 7. Apparatus for photographing a composite single frame projection and cartoon drawing.

The device for making enlargements from motion picture negatives is shown in Fig. 8. This machine is semi-automatic in action and works somewhat like a printing press. A camera head connected to a 1-to-1 device feeds the film one frame at a time. The feed is actuated by a motor driven tripping device. The paper, usually glossy bromide, is placed upon the easel (face toward the light) and the clutch thrown in, thus bringing the platen against the paper and throwing the punch into operation. The punch makes the necessary registry holes while setting an electric switch which actuates the tripping mechanism that revolves the exposure shutter. The platen is now withdrawn and another frame of film automatically brought forward in the camera head. Everything is then in readiness for the next exposure. It is possible to make 500 enlargements an hour with one of these machines. The enlargements must be developed in quantity to insure uniformity of tone; therefore, racks holding 100 sheets are used. The rack is immersed in a tank of developer and properly stirred. The succeeding washing and fixing operations are carried through without removing the paper from the racks. The enlargements are dried on ferrotype tins. If properly made, they retain most of the photographic quality of the original negative. The animated figures upon sheets of celluloid are laid over

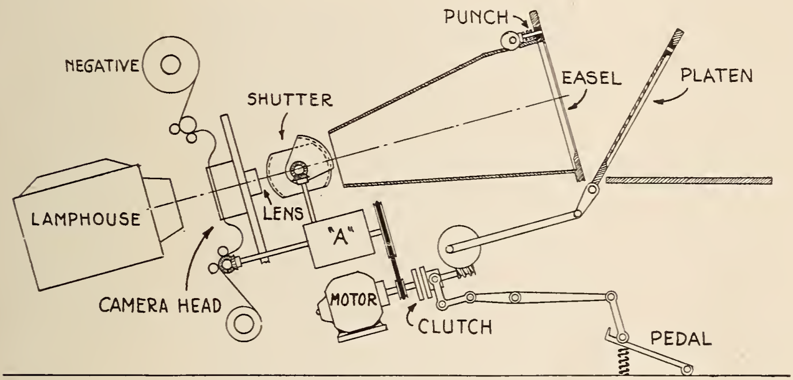


Fig. 8. Device for making single frame enlargements on paper.

the enlargements and the composites exposed in the cartoon camera. If the enlargements are made from a negative of high quality, the resulting film will be surprisingly good photographically; quite unlike the results obtained in the common practice of duping.

Unique and lifelike animation may be obtained by reproducing in line drawing a figure photographed in real action. A tracing machine consisting of a projector which throws an image of the film upon a sheet of paper is used. The artist traces the outline of the figure in the successive phases of motion. The subsequent operations to produce the finished product follow standard practice.

The animated drawing, cartoon and technical, is constantly undergoing development and refinement. Although some obsolete methods are still in use, the demands upon the animator are forcing him to engage his wits in efforts to improve the product by the use of mechanical means.

DISCUSSION

Mr. Norrish: What sizes of enlargement are made from the motion picture film?

Mr. Norling: Almost any size convenient to handle—the larger ones are more costly but give better quality in the finished product than the smaller ones. Enlargements made on 8×10 paper were the most practical all around.

THE EFFECT ON SCREEN ILLUMINATION OF BUBBLES, SEEDS AND STRIATIONS IN THE BULBS OF PROJECTION LAMPS

L. C. PORTER AND W. S. HADAWAY*

IN BLOWING glass bulbs for projection lamps, there occasionally occurs in the glass small bubbles or slight ridges on the glass known as "striations." Sometimes, a small mold mark is left in the glass. It seems to be impossible to entirely eliminate all of these little flaws. On several occasions, complaints have been received that blisters in lamp bulbs have been the cause of poor screen illumination.

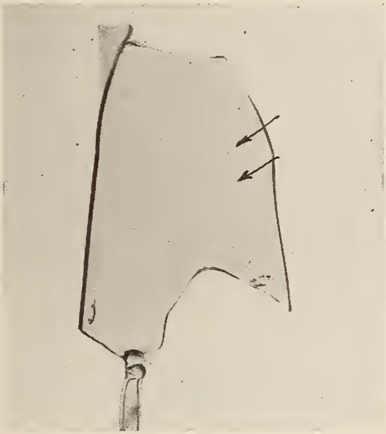


FIG. 1. Blistered glass used for test.

All of these complaints have been indefinite, and no specific data seemed to be available on the subject. In order to determine definitely whether or not there was any such detrimental effect, the authors, conducted a series of tests on lamps of various sizes and in different types of projectors.

In order to obviate the difficulty of finding lamps in which bulb blisters, or seeds came on or close to the optical axis, a piece of glass having such blisters (Fig. 1) was placed against the bulbs of the lamps under test.

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For the tests, the entire lens systems were mounted on an optical bar, Fig. 2. The piece of glass with the seeds was held in various positions, i.e. between the light source and the condenser, corresponding to the front of the bulb; between the light source and the spherical mirror, corresponding to the back of the bulb.

The exact data on the various tests are as follows:

Diameter of condenser lens	1–1/2″
" " projector "	3/4″
" " mirror "	3–3/4″
Radius of curvature of mirror	2″

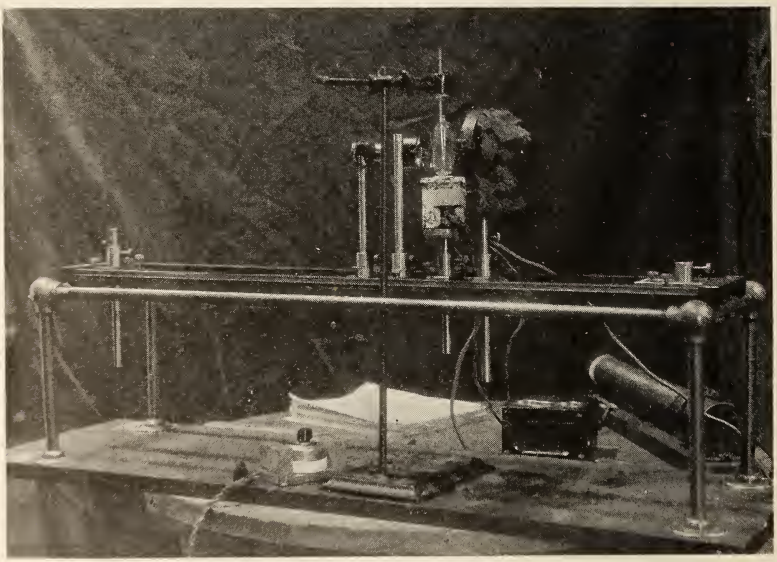

Fig. 2. Test Bench.

light source dimensions of 4 ampere, 25 V. lamp	3/16″×3/16″
" " " "2 " 14 " "	3/32″×1/8″

Fig. 2 is a photograph of this set up and shows how the blistered glass was held so that the blister would be in line with the optical system.

Test No. 1:

4 ampere, 25 volt, T-8 lamp (4-section filament)
Blistered glass in rear of lamp

Distance of mirror from light source	1–3/4″
" " blister " " "	1/2″
" " condenser lens from light	1–1/4″
" " projector from condenser lens	2–1/5″
" " " " screen	8–1/2 ft.

Fig. 3 shows a photograph of the screen.

Test No. 2:

4 ampere, 25 volt, T-8 lamp (4-section filament)
Blistered glass in front of lamp
No mirror used

Distance of blister from light source	1/2″
" " condenser lens from light source	1–1/4″
" " projector from condenser lens	2–1/4″
" " " " screen	8–1/2ft.

Fig. 4 shows a photograph of the screen.

Test No. 3:

4 ampere, 25 volt, T-8 lamp (4-section filament)
Blistered glass in front of lamp
No mirror used

Distance of blister from light source	1
" " condenser lens from light source	1–1/4″
" " projector from condenser lens	2–1/4″
" " " " screen	2–1/4″

Fig. 5 shows a photograph of the screen.

Test No. 4:

2 ampere, 14 volt, T-8 lamp (2-section filament)
Blistered glass in rear of lamp

Distance of mirror from light source	1–3/4°′
" " blister " " "	1/2″
" " condenser lens from light source	1–1/4″
" " projector from condenser lens	2–1/4″
" " " " screen	8–1/2 ft.

Fig. 6 shows a photograph of the screen.

Test No. 5:

2 ampere, 14 volt, T-8 lamp (2-section filament)
Blistered glass in front of lamp
No mirror used

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Distance of blister from light source	1/2″
" " condenser lens from light source	1–1/4″
" " projector from condenser lens	2–1/4″
" " " " screen	8–1/2 ft.

Fig. 7 shows a photograph of the screen.

Test No. 6:

2 ampere, 14 volt, T-8 lamp (2-section filament)
Blistered glass in front of lamp

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

No mirror used

Distance of blister from light source	1″
" " condenser lens from light source	1–1/4″
" " projector from condenser lens	2–1/4″
" " " " screen	8–1/2 ft.

Fig. 8 shows a photograph of the screen.

Test No. 7:

The piece of blistered glass was placed in front of the 21 candle power, automobile headlight lamp in a Brayco projector, so that the blister was against the bulb and in line with the filament and the condenser lens. The effect is shown in Fig. 9.

Test. No. 8:

The blistered glass was placed in front of the lamp in a Spencer lens stereopticon, so that the blister was in line with the filament and the condenser lens. The lamp used in this machine was a 400-watt, 115 volt, T-20 lamp with light source dimensions of $\frac{1}{2}'' \times \frac{1}{2}''$.

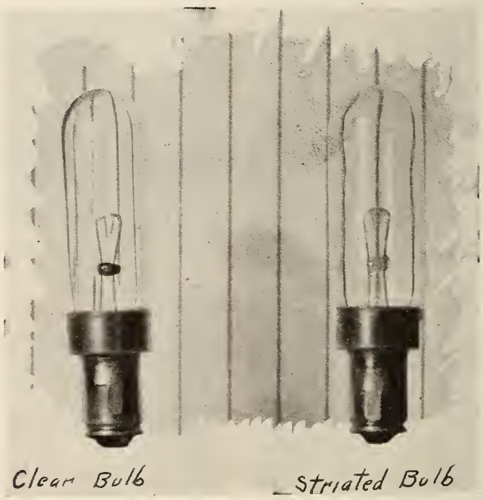

FIG. 13

The blister was held against the bulb and was about 1-¼″ from the light source. The diameter of the condenser lens was 4-½″, and the diameter of the projector lens, 2-½″. The light source was about 4-½″, and the diameter of the projector lens, 2-½″. The light source was about 4-½″ from the condenser lens.

Fig. 10 shows the screen illumination obtained.

Test No. 9:

The blister was placed in front of and against the bulb in a moving picture machine equipped with the standard 900-watt 30 volt, motion picture lamp. The light source dimensions were about 7/16″×½″. The diameter of the condenser was 4″, and the projector lens, 2½″. The distance from the light source to the condenser lens was 2″. The blister had no effect upon the screen illumination.

Test No. 10:

Fig. 11 shows the screen illumination obtained when a regular ½ ampere, 12 volt, T-4½ bulb lamp is used in a Pathex projector. Fig. 12 shows the screen illumination with the same type of lamp in which the bulb is badly striated. Fig. 13 shows a photograph of the regular lamp and lamp with striated bulb used in this test.

Conclusions:

These tests show that small blisters, striations, or other imperfections in the bulbs of lamps used in small projectors have some effect upon the screen illumination when the blister is in that part of the bulb which is in line with the light source and mirror or light source and condenser lens. When the blister is in that part of the bulb which is in the rear of the lamp; that is, between the light source and mirror, the effect upon the screen illumination is slight. When the blister is in front of the light source, between the light source and condenser lens, the effect upon the screen illumination is serious. This is particularly true in small projectors which have condenser lenses of 2″ diameter or less and use a lamp of small light source dimensions, such as the 4 ampere, 25 volt, T-8 bulb lamp. In even the worst case, however, the shadow on the screen probably would not be noticed with a slide or film in use. The larger the light source and condenser lens, and the greater the distance between light source and condenser lens the less serious will be the effect upon the screen illumination.

DISCUSSION

Mr. Townsend: In regard to definite dark spots on the screen, I am able to overcome these very well by using a relay system. Mr. Hill's method also is effective, the image being so far out of focus when it reaches the screen that these dark spots are not apparent.

Mr. Porter: What Mr. Townsend says is true. We were testing lens systems in use. We know that improvements can be made.

SUBTRACTIVE COLOR MOTION PICTURES ON SINGLE COATED FILM

F. E. Ives

CONVINCING results in motion picture projection and additive process trichromatic photography were contemporaneous, and it was natural to ask if the two arts could not be combined. The first recorded suggestion is the British patent of Lee and Turner, two young men who were employed in my workshop in London and who with my consent patented a scheme which I disclosed to them but which I told them was of more theoretical than practical interest at that time. I considered it a great joke when their patent rights were afterwards sold for real money; but, as I predicted, the method was not practically satisfactory.

The Kinemacolor, which followed, by eliminating the blue element of the trichromatic process, sufficiently simplified the procedure to yield results which met with a limited practical success in England while a novelty, but the American Company failed after using up great sums of stockholders' money. Friese-Green and others tried to improve upon this process, and Gaumont demonstrated a method which is really nothing but an application of the method of additive trichromatic projection which I used for "stills" in my lecture demonstrations in the nineties of the last century. The additive process can be made to give beautiful results under certain conditions but not under conditions which make it practicable for use in connection with black and white motion picture projection in the theatres. It is quite necessary for practical success that the color film be interchangeable with the ordinary black and white film without complication or change of speed in the projection apparatus. The additive process, by reason of color screen absorption also requires a greatly increased source of illumination to match up with the regular black and white projection, and this fact alone would condemn it for commercial exploitation in the regular motion picture theatres. It is my opinion that the additive process of color motion picture photography is as dead a commercial proposition as the photochromoscope system in still color photography.

Mejia and Thornton were the first to propose the subtractive process for this purpose, also using two-color analysis and printing the images on opposite sides of the film. Excellent work has been done by this process and also by printing on separate films and cementing them together, which I was the first to propose. Various color print making processes have been used for this purpose, such as that of Capstaff, chemical toning, dye toning, and wash-out relief printing with dye coloring. The last mentioned method, in use by the Technicolor Company, is substantially the method of my U.S. patent 1,186,000, which I applied for in March, 1915. All of these methods are capable of yielding perfect results in competent hands, and the Technicolor Company has already turned out a good deal of really beautiful work, though deficient in greens and yellows; but the complication and cost of these processes is a great limitation and drawback, and I resolved to find means to make the color prints in the single coating of ordinary positive motion picture film, so that color motion pictures could be supplied at greatly reduced cost free from the acknowledged objectionable features of film coated on both sides.

I obtained the first convincing results in February, 1914, by the method of my U.S. patent 1,170,540, Feb. 8, 1916, and improved upon this with the process of my U.S. patent 1,278,668, Sept. 10, 1918. While the results are perfect, the bichromate and iron printing processes with which I obtained one of my images were too slow to be satisfactory from a commercial production standpoint.

Meanwhile, Fox had domonstrated a method (U.S. patent 1,166, 123, Dec. 28, 1915*) in which the two images were produced in the original silver bromide coating, the second image in the uneven residual layer of silver bromide left after the production of the first image. I have produced some good results by Fox's process, but it is very difficult to operate with success, and it is obviously unreasonable to depend upon an uneven residual layer of silver bromide in which to produce the second print. It can just be made to work out if thin negatives are used or the emulsion is colored with yellow dye to limit the penetration of light, and provided that the hypo treatment required to prevent redevelopment of the first image is not overdone but is yet sufficient. This difficulty I eliminated by converting the silver base of the first print, after blue-toning, back to silver bromide, so that the second print as well as the first is made in a full layer of silver bromide. Incidentally, this procedure,

* Applied for seven months after Ives' application for patent 1,170,540, and one year after Ives' practical demonstration.

besides giving better results, is, as finally worked out, simpler and far more dependable.

At our Washington meeting in 1922, I showed results by this process in color motion pictures without any of the color fringing then characteristic of other processes. My negatives have always been made by simultaneous exposure from a single viewpoint, and the device which I then used was that of my U. S. Patent 1,383,543, July 5, 1921. Since then I have obtained some excellent negatives using an ordinary single motion picture camera with two specially prepared sensitive films run in face-to-face contact between a glass plate and a velvet pad, the method of my U. S. Patent 1,329,769, Nov. 4, 1919, which I think will meet every practical requirement when Dr. Mees can speed up the transparent green sensitive emulsion a little more. A dye-stain color screen coating which I patented is an important element of success of this method.

In the matter of color rendering, a two-color process has obvious limitations, but these have been reduced to a minimum in the subtractive process, first, by the fact that pure whites are obtained, and, second, by using a dichroic red-to-yellow image in place of a simple red (U. S. patent 1,376,940, May 3, 1921), whereby blue skies are obtained with green foliage and orange and yellows in fruits and flowers. Cobalt blue reproduces as black, and purples as browns or oranges, but the total effect is in most cases not only pleasing but highly satisfactory and very far superior to results obtained when using a simple red. It is my hope that this process may be developed strictly upon its merits and not by exploitation as a get-rich-quick proposition, as were some of the methods which proved commercially impractical. Photographic processes involving the perfect co-ordination of a considerable number of separate factors, the development of skillful and experienced labor, and perfection of special labor-saving equipment will not bear the kind of forcing which is favored by the average business promoter.

It should be possible eventually to produce color motion picture prints of fine quality at twice the cost of black and white, and they will then very largely supplement, but never altogether replace, black and white motion pictures.

DISCUSSION

Mr. Wall: There are one or two points which are interesting to me from a technical point of view. I should like to direct Mr.

Ives' attention to the fact that the first projection was not made by Lee and Turner. The first man to project color pictures was a German. Caille was the first to suggest the use of one emulsion film for obtaining three colors, not double coated film or film cemented together. Caille's process is a little difficult but can be worked out.

There is one point which these inventors have omitted altogether. They don't seem to know it is possible to convert a silver image into three silver salts non-developable in an alkaline developer.

The second point is that none of these inventors—Kelley, Mannes, or Godowsky, etc.,—realize what the action of these solutions is. They all know they desensitize, and if they would turn back to the classic work by Mees and Sheppard of 1907 they would find them classified as catalysts. After you have treated your image, you can wash as long as you like to take out the desensitizers from the gelatin, but we don't print the second image on gelatin; it is on silver bromide, and you must take your catalysts from the silver bromide grains, and this can be done with what Mees and Sheppard called "negative" catalysts, and you restore not the original sensitiveness of the silver bromide but very nearly the original. I think the process would be simplified if the inventors took up these few facts and then worked them out.

Mr. Ives: The first two references which Mr. Wall gives are new to me. They should of course go on record and be taken for what they are worth. I doubt if they affect the substantial accuracy of my statement as applied to color motion pictures, and that is a matter of minor importance anyway.

Mr. Wall stresses the obvious fact that the silver bromide produced by reconverting the base of the blue-toned silver image is not necessarily of equal sensitiveness with the other silver bromide in the film. One of my experiments was to take an ordinary black motion picture film positive developed and fixed in the ordinary way and blue-tone it. I submitted this in the dark room to the action of my bromide resensitizer, which converts the bases of the blue print to silver bromide, placed my finger over a portion of the picture, and gave it a flash of light. That which was covered by my finger did not redevelop, while the rest developed black, proving that the silver base was converted to light sensitive silver bromide, and

I succeeded in making the entire layer of sufficiently even sensitiveness to develop even tints on flash exposures from either face.

Mr. Wall thinks the process would be simplified if some of the matters which he mentions were taken up and worked out. That is answered by the fact that nothing could possibly be simpler than the method of my U. S. Patent 1,499,930, according to which by a brief immersion in a single bath the silver image is toned blue and its base converted back to light-sensitive silver bromide.

PROBLEMS OF A PROJECTIONIST

Lewis M. Townsend*

THE PROBLEMS of projectionists are so numerous and so widely different in their nature that I have been very careful to keep the last word of the title of this paper singular. If one were to attempt to write on the problems of projectionists in general, I fear he would never live to see the end of that one article. This is therefore confined to my own problems. These I shall state only in a practical way with the hope that others in the Society may help to supply either practical or technical information which will lead to the reduction of my troubles as well as those of many other projectionists and theatre managers.

We shall start with the receipt of a brand new film for previewing. The majority of film received at present is waxed by a good waxing machine which places a thin line of wax over the perforations. The wax is applied in a molten state, and no more is applied than is absolutely required. A few exchanges, however, persist in trying to apply cold paraffin to the film. The result is that eight or ten times as much wax is used as is necessary. This gums up the sprockets of the projector, lodges in the aperture, and makes a very displeasing grillwork along the sides of the projected picture. Quite often so much wax will spatter on the lens that it is necessary to stop in the middle of a picture to clean the lens. Later, the excess wax spreads over the entire film and very often discolors any toned portion. It is strange that exchanges will continue to ruin their own goods year after year in this manner. It is still very common to receive new film on reels that are ready for the junk heap. Quite a number of reels are, in my estimation, ready for the junk heap before any film has ever been placed on them. Some exchanges still continue to use cheap, wobbly, or worn out reels to mount their prints costing hundreds or thousands of dollars. Less than a month ago I received a print of the "Black Pirate" done throughout in Technicolor, with the usual amount of printed instructions to the projectionists to use care, caution, etc., in handling

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the film to prevent scratching. This print had not been through a projector more than two or three times, but the reels were in such a bent and dilapidated condition that we were forced to stop the projectors and have the entire feature rewound on good reels before we could finish the preview. The last fifty or one hundred feet of each reel was so badly scratched at this early date in its life that we would have refused to use this particular print for a regular showing in the Eastman Theatre.

Next, we shall take the receipt of a feature or other film for showing, some five or six weeks after pre-viewing. The punch mark nuisance has abated somewhat but is still with us. We also have stickers of all shapes, sizes, and description placed not only by *operators* but also by exchanges themselves. I believe the only way to eliminate this nuisance and waste of film is for the producers themselves to get together and adopt some safe and sane method of ending their reels so there will be no doubt as to when the end is coming. Some producers now arrange a fade-out at the end of each reel. This proves that it is possible. Other producers wilfully commit the blunder of ending one reel with a close-up of one person and starting the next reel with a close-up of another person. This is inexcusable. I see no reason why they should not send out a cue sheet describing the action at the end of each reel. It may be well enough for the DeLuxe houses to make their own cue sheets, as we do, but bear in mind that many, many theatres do not receive their film three or four days ahead of showing. Many are lucky to receive their show a few minutes before the theatre opens. Going further, I can see no reason at present for making leaders which will project "End of Part One," "Reel Two," etc., on the screen. Why not use opaque film for leaders and print this information in such a way that it can be read by the projectionist but will not be projected? Several feet of film and, what is more important, several feet of action are wasted daily by the cutting off and replacing of these leaders.

My problem at present in regard to film condition centers on scratched film. Unless film is absolutely first-run, scratches are always present in a greater or less degree. I believe that small reel hubs, high speed rewinds with poor tensioning devices, and worn magazine valves are the chief causes of scratching. I think that the adoption of the five-inch hub as standard would be very beneficial to the majority of theatres and only slightly objectionable to a small minority. You may say, "What about the portable projectors and small theatres that still use the small magazines?" I say "Why cater to the minority when the vast majority would receive a direct and decided benefit?" This unnecessary winding and rewinding on small hubbed reels causes more scratches than any other one thing. For a rewind, we use two Simplex take-up brackets and lower magazines. The idler side is equipped with the regular take-up tensioning device. This is light and even. The driven side is geared in such a way that it takes four minutes to rewind a two

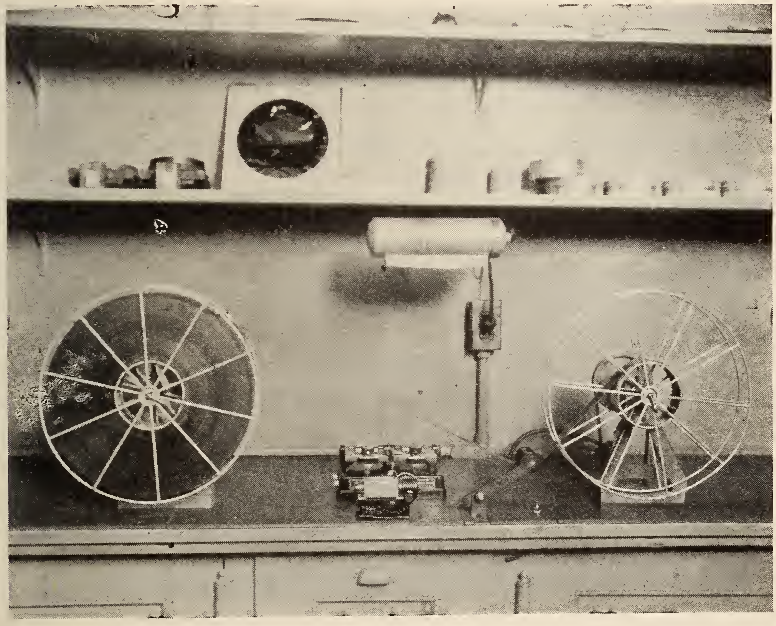

FIG. 1 Automatic Film Rewinder

thousand-foot reel of film, the hub being five inches in diameter. Near the reel onto which the film is wound a hard guide roller is mounted on an arm having a vertical swing. The roller guides the film evenly on the reel with no slopping sidewise. The swinging arm is arranged in such a way that when the end of the film goes through or in case of a break the arm drops on a radio plunger switch and stops the motor. A photograph of it with magazines removed is shown in Fig. 1.

My greatest problem today is to be able to run a thousand-foot weekly, a two-thousand-foot comedy, and an eight-thousand-foot feature on a two-hour schedule which includes also an eight or ten-minute overture and a five or ten-minute act. This cannot be done without speeding. We have found at the Eastman Theatre that at least the above amount of variety is necessary to make a well rounded program. What do we do? Instead of using eighty feet per minute as a standard projection speed, we project at from ninety to one hundred feet per minute. We have one hundred and twenty minutes for the complete show. Subtract ten minutes for overture and ten minutes for an act or acts, and we have left one hundred minutes for film. This will allow us to show approximately nine thousand feet of film. We pick the weekly to make about eight hundred feet. We reduce the comedy to about twelve hundred feet and take out about one thousand feet from the feature. Each of these footages are approximate, bearing in mind that the whole show must not be much in excess of nine thousand feet. How do we do it—by cutting. It is no easy job. This is the way we go about it. The managing director, the musical director, and I watch the picture through at the first pre-view, after which we confer as to what can be eliminated. At this time I estimate just how much the film will be reduced in footage. The speed and running time are then decided. I make an index card containing this information and file it. Later, when the picture is received for showing, I have it run over again and make the necessary cuts. This work usually takes six or seven hours. Producers and exchange managers object to having their pictures cut; this will be done as long as they continue to make features much in excess of seven thousand feet or make comedies two thousand feet in length which would be much better if only one thousand feet long. Of course we do not cut a thousand or two thousand feet from some particular part of the picture. It is gone over, reel by reel, and we take out only minor incidents which do not have a direct bearing on the story and unnecessary detail or padding, of which there is usually a great sufficiency.

Once the picture is cut to required length, it is ready for scoring. We usually spend the greater part of three days running the picture over and over for the musical director to get his music properly arranged.

In order to have a smooth running show, free from breaks, it has been found necessary to inspect by hand all film included in the program. This is not done because of worn or defective perforations but on account of bad laboratory splices. Apparently the majority of laboratory splices are good. Features have been received from the largest producers in the past year in which poor cement had been used. I think this mainly, however, the result of improper handling. Many do not seem to realize that a loose cork will soon ruin an entire bottle of cement. On these apparently good splices, if you just pick at the corners of the joined parts, they will open up and with only slight effort they separate very easily. Frequently the cement looks and acts more like library paste. Hand inspection is the only remedy. It is also necessary to remove a considerable quantity of oil, grease, and dirt from films as received even if only five or six weeks old. This is done by hand. Pads of long nap silk velvet are made, and saturated with carbon tetrachloride. The film is run through these. An electric desk fan is trained on the film in such a way as to evaporate all surplus solvent from the film before it reaches the reel, two men being used for this work. One cleans the film; he keeps the second man busy washing out the velvet pads. One piece will clean about fifty feet of film; then it must be washed out. This process takes about thirty minutes to a thousand-foot reel or four hours to properly clean an eight-reel feature. After inspection and cleaning, the film is wound on two thousand-foot reels for showing. To obviate the possibility of a man putting in the wrong reel or putting in a reel backwards (without rewinding), we have found it necessary to use plain white undeveloped film for leaders at the start of each reel with the number of the reel plainly punched on the leader, and to use a colored undeveloped leader (I use amber) at the finish of each reel. This might seem an unnecessary precaution, but I was forced to discharge two otherwise good men a couple of years ago for putting reels in backwards. It has never happened since.

Now, let us say a few words in regard to organization and equipment. *Any theatre that desires to sell motion pictures to the public must do so through the medium of good projection.* This depends *entirely* upon the *organization* of the projection department and its *equipment*. At the Eastman Theatre, I am in full charge of the projectionists and equipment. I and no one else is held responsible for the projection. Although we have the best equipment money can buy, this would soon deteriorate unless properly cared for. The projection department consists of seven men including myself.

We use four projectionists, two at each shift, for running the regular show, one projectionist for screening purposes, and an artist who assists me by preparing designs, etc., for projection of color and lighting effects. I am not required to do any actual projection of film. If there is more work than the regular men can do properly, I call in other men at overtime rates for this extra work. The screening man and designer are also able to do general office work, take care of receiving, daily listing of all film on hand and shipment of it. The projectionists who run the regular show are picked for their individual ability. We must consider that a good projectionist must be a student of mechanics, electricity, and optics at least, to say nothing of physics, chemistry, and many other branches of science which could very reasonably be called a necessary part of his education. If we were so lucky as to find a man with all of these requirements, the whole would be spoiled if his physical condition were impaired or his eyesight should happen to be bad. I believe that, if a would-be projectionist discovers that he has lung trouble, is very near sighted, or is color blind, he should immediately seek other employment, because he will never be successful as a projectionist and will only be a disappointment to himself and others if he tries to stick to it. After taking all of the above into consideration, our men are picked in such a way that one man is good on a few of the requirements and another is good on some of the others, managing between the four to cover the territory. The work is arranged in such a way that one is accountable to me for the condition of one part of the equipment and another for some other part, and so on.

We now reach the point where the show goes to the main projection room for a regular week's run. During the time that the film has been in preparation, the designer has been working out, under my direction, special effects that will symbolize the different, numbers on the program, such as weekly, comedy, feature, etc., as described by Mr. L. A. Jones and myself in the S. M. P. E. Transactions No. 21. All color and lighting effects are rehearsed, after which every detail is written out, including the speed, footage, and time of starting and ending of each number on the program. Only by the written method can we be sure that one show after another will be exactly the same. It is essential that every show be the same even to the timing of color effects, which cover the curtains while they are closed between each number on the program, because these effects are also timed with the musical score. We used to rely on hand inspection of the film to avoid breaks during the run of a show, but we have since changed to the use of an inspection machine. Sensitivity of the machine is tested daily with a test film with all possible defects numbered in such a way that, if the machine fails to stop on any number, proper adjustment be made at once. Without using the test film, the machine would hardly be reliable. It is necessary to run the film through this machine only once daily to insure the theatre against breaks.

Besides the nine projectors under the roof of the Eastman Theatre and Eastman School of Music, there are three in each of our other two theatres, the Regent and the Piccadilly. Out of the fifteen projectors, three are equipped with high intensity arcs, six with reflector arcs, five with Mazda, and one with a regular arc. There are the following projection distances fifteen, twenty-five, thirty-five, eighty, ninety, one hundred, and one hundred and sixty feet. After many experiments, the white cloth screen with rubber backing seemed to give the best results under various conditions and these are used throughout. The high intensity arc is used on the one hundred and sixty foot distance. The light from this was very unsatisfactory as to color and uniformity of screen brightness until the relay system was used. This increased our screen brightness twenty-five per cent, in the center of the screen and thirty-three per cent, at the corners. While the light has much less blue in proportion than before, it is still necessary to use correcting filters while projecting color films. With the Mazda also, it is true that a clear field was not obtained until the relay system was adopted. This particular relay system uses an aperture lens, which is capable of converging the light beam into an objective lens of small diameter. The reflector arc, while it gives plenty of economical illumination, also delivers plenty of heat to the film. This heat in itself sets up many focus troubles which have been encountered by only a few projectionists before. The light beam in this case usually fills the objective lens to its full aperture,which tends to reduce the depth of focus. At the same time, the film is heated to such an extent that each separate picture buckles and bellies toward the light source (away from the objective). This buckling varies with the density of the film. Thus, a title with a black background will buckle most, and a letter written on a white background will buckle the least. These are the extremes. In between, there are hundreds of different densities, each absorbing a different amount of heat and buckling accordingly. If the lens happens to be of short focus or especially large aperture, the only way to keep the projected picture in sharp focus is to refocus with each change of density. My only remedy is to use an objective lens of relatively small aperture. This assures enough depth of focus to take care of the buckling. In general, it is against my good judgment to use an objective that has a free aperture of more than F/3. At present we are able to get all the illumination required without resorting to exceptionally large aperture lenses and taking chances on losing sharpness and definition by so doing.

Looking ahead, I believe that in time the reflector arc will be replaced by an angle arc mounted back of six or eight-inch diameter condensers in connection with a relay system using an aperture lens which will converge the light beam into a small aperture objective lens. I believe that the same system will be used with either high or low intensity carbons as the condition may require. In connection with this, a revolving shutter located just back of the aperture (between the condensers and film) will of necessity be introduced. This would reduce the heat on the film by at least one half. The shutter would also have the advantage of being a standard width for all sizes of objective lenses. Another thought is that with the coming of more and more colored films the projectionist requires information which will enable him to correct the color of his light to produce the proper result on the screen. Those who are producing color films at present should make a careful study of the different colors of projection light sources and furnish the proper filters to meet the conditions. Otherwise, they are doing themselves and their product an injustice by allowing it to be shown under many different light conditions, a number of which are decidedly wrong and give the public a false impression of color photography.

DISCUSSION

MR. HILL: Mr. Townsend says he favors the use of a lens in the film aperture which converges the light into an objective of low numerical aperture. I, too, favor the result but not the method; however, Mr. Townsend and I have arranged to settle this matter elsewhere.

I am glad to know that the Eastman Theatre is going to all the trouble of editing their films to shorten the running time rather than the more widely practiced expedient of excessive speeding, An exhibitor who jams two hours' entertainment into an hour and a half is giving the public short weight; he is no better than the grocer who sells a pound of butter weighing thirteen ounces. I'm glad to know that the Eastman Theatre has adopted the more ethical method of deleting the "less nutritious" portions of the show.

President Cook: I don't quite agree with Mr. Hill's statement that it is the same as a grocer who sells thirteen ounces for a pound. They still get the same amount but it is rammed down their throats more quickly than they can assimilate it,

Mr. Palmer; I want to ask Mr. Townsend about cutting down the footage-whether they have asked the exchanges to do that instead of doing it themselves. Being in the production end of the business, I think that the exchange might be able to do that better than the projection operator or the man in charge of the projection.

Mr. Townsend: We had one experience with an exchange cutting a picture, and after that we did not care to take another chance; they simply eliminated five hundred feet in one chunk, which left out part of the story, and everybody going into the theatre noticed it; whereas, we try to use judgement. When I desire to get five hundred feet out of a picture, I take only a small amount of each reel and am very careful about it. I see the picture at the pre-view, then it is run again, reel by reel. I don't rely on my memory to carry through a whole feature. We don't eliminate a part of the story or an incident in the story that is important to the story itself. We eliminate only the by-play and very apparent padding.

Mr. Denison: I don't think the theatre has any right to cut pictures. The picture is properly cut in the studio and is in complete form. I do not think projectionists are qualified to re-cut a picture. We do not even attempt re-cutting in exchanges outside of lifting censored parts. We have tried to stop the cutting of our pictures the theatres. If pictures are too long or padded, the matter should be taken up promptly with the producers. Unskilled cutting of pictures in the theatre certainly mars the story value of the picture.

Mr. Richardson: I can't remember the time when I have seen a production on the screen that would not be benefited by eliminating footage. Padding operates tremendously to the damage of the show in many theatres because they want to run a topical, a feature, and a comedy in the allotted time, and it is not long enough to accommodate all the things the manager wants to include. I have long said, and say again, that one of the highest functions of the able projectionist is to be able to look over the film and eliminate enough of the padding present in practically all productions to bring it down to the footage which can be put through without overspeeding.

THE USEFUL LIFE OF FILM

F. H. Richardson*

THE ULTIMATE and only purpose of the motion picture industry, insofar as theatres, are concerned is to provide a program which the theatre will be able to sell to the public at a profit and to continue to do so indefinitely. The purpose of the motion picture is, in the main, to supply entertainment and amusement. True, there often is an educational element and a viewing of the high spots of the world news of the week intermixed, but the fact remains that at least nine tenths of the motion picture "show" consists of amusement and entertainment.

The foregoing will, I believe, be accepted as just plain fact, concerning which there need be no debate. If that be true, then, may we not also agree upon the statement that the motion picture industry will succeed exactly in proportion to the general excellence of the entertainment it provides and its power for providing amusement to the public?

And, now, gentlemen, I ask that you who hear my argument and those others who may read it in the transactions of this Society consider for a moment what your reaction would be were you to visit the Capitol, the Rivoli, the Colony, of New York City, or any other really high grade motion picture theatre—a theatre of similar class to those named—and see projected to the screen, a feature in which were long, wide scratches and thousands upon thousands of small ones, all so filled with dirt as to be either opaque or semi-opaque, with breaks in the action of the play every few feet caused by pieces of film having been cut out in the making of repairs to the print, and with an occasional bobbing up or down of the picture as a whole as a wide, stiff splice passes through the projector.

What, I ask you, would be your mental reaction to that sort of thing? Would you call it satisfactory or even fairly good entertainment? Assuming that, aside from the faults inherent in the film itself, the projection was high grade, would you be satisfied. Would you not, as a matter of fact, wonder if the theatre management were not verging upon insanity to inflict such a thing upon its audiences? Would you not really feel a bit embarrassed at your connection

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with an industry which would perpetrate such crudeness or permit it to be perpetrated in its name? I defy you to look me in the eye and say you would not.

And, yet, gentlemen, that is exactly and precisely what is being done every day, in greater or less extent, in thousands of theatres in this country and Canada alone. It is done as a matter of course, and few seem to have even the remotest idea that it represents neither good practice nor good business. The industry calmly inflicts upon the audiences of one theatre that which it would regard as little less than an insult to offer to the audience of another.

This is so because through the years the custom has grown up of using (and abusing) the new prints in what are known as "first run" theatres until the various faults I have named and others become visible on the screen, whereupon, instead of replacing the worn prints with new ones, they are started on a veritable toboggan slide, the foot of which rests in the cheaper small-town and city house and in the village theatre. And, gentlemen, they arrive at the foot of the slide in such condition that their infliction upon theatre patrons constitutes what can only rightly be termed an outrage.

All of this brings us to the question, what is the useful life of film, a query which has heretofore been answered about in this way: "The useful life of film is the number of months between the time of its first projection and the time when its condition is such that it cannot possibly be rented no matter how low the price--until it is utter, absolute, and complete junk and nothing else but junk. Gentlemen, I take issue with this sort of thing and declare it to be very poor business procedure. I hold that it injures the industry and every one connected with it, including the owners of the prints who keep them in service until the very last possible cent in low rentals has been squeezed out of them. I hold that such procedure injures the theatre which inflicts such junk upon its patrons far, far more than the advantage "gained" by reason of the low rental price. From any and every angle and viewpoint I hold it to be wrong. Please understand that I am fully aware of all those various points involved when I say I AM OF THE OPINION THAT IT IS AN ERROR TO HOLD PRINTS IN SERVICE AFTER THE VALUE OF WHAT THE AUDIENCE SEES IS APPRECIABLY DEPRECIATED IN ENTERTAINMENT AND AMUSEMENT VALUE BY REASON OF DEPRECIATION IN THE PHYSICAL CONDITION OF THE FILM ITSELF. I am thoroughly convinced that retaining film in service after the point is reached where the entertainment value of the "show" is appreciably lowered by the damage thereto means loss of money to (a) the exhibitor who uses such film, (b) the film exchange which owns it, and (c) the producer. "How can that be," do you ask, especially as it applies to the exchange,—a fair question. Unless I can answer it with sustained argument, my claim falls to the ground of its own weight.

My whole argument hinges on the willingness of the public to pay reasonably for quality in its entertainment, just as it is willing to pay reasonably for quality in other things. You very well know that the public in great cities, the public in small cities, and the public in villages is much alike in at least one respect, namely, it will buy according to its means of that which appeals to it, always provided the goods seem to be "worth the money." That is just as true in amusements as in goods of other sorts.

There is no portion of the human family more greatly in need of motion picture entertainment than is that great majority which supplies the patronage to the smaller, cheaper city theatres, the small town theatres, and the village theatre. As a general proposition these who patronize large theatres, such as the Broadway houses, paying relatively high admission prices, are able to and do purchase other forms of amusement, including motoring, in generous amount. On the other hand, the great bulk of those who supply patronage to the smaller motion picture houses have relatively few and simple forms of entertainment and amusement. So far as theatrical entertainment is concerned the "movies" form their only source of supply except in cities for an occasional trip to the larger, more expensive motion picture theatres where tableaux and more or less elaborate musical programs form a part of the divertissement offered. They do not feel able to afford the more costly forms of theatrical and other amusements very often. Price of admission is an important item to them, it is true but, it is also true that the great bulk of these people could afford to and would pay more money for their admissions if they felt that the entertainment offered was worth the money. Few of them buy the cheapest thing, in dry goods, in groceries, or in anything else. If the cheapest thing, the most expensive thing, and a medium priced article be laid side by side, it will be found that the cheapest and the most costly will usually be passed by, and the not too expensive goods of fairly good quality will be bought.

My contention is that this same thing holds good in theatrical entertainment! Does it seem reasonable to suppose that people who pay a low price for admission to a theatre where scratched wrecks of films are used would not be willing to pay a moderate advance in admission were films in mechanically perfect condition employed?

In the first case, they see a screen image which at least is far from perfect and which in a great many cases is very bad indeed. The action is broken by eliminations caused by repairs to the films. The picture is unsteady, and there are other serious faults. In the second example, they see a screen image which is perfect, at least with respect to the faults named. There is no "rain" at all, and no breaks in the action. Aside from such unsteadiness as may be caused by wear or lack of proper adjustment in the projector itself, the picture is rock steady, and if the speed of projection be approximately correct and the screen illumination satisfactory, the audience sees a perfect photoplay.

Gentlemen, do you for one moment believe that the average person would not be willing to pay a reasonable advance in admission price to see such a picture as against the scratched-up, unsteady, jumpy thing we see today in a very large number of the smaller theatres? Don't you really believe that with the films in use in all theatres in approximately perfect mechanical condition, the business of the industry, taken as a whole, would not only increase but would increase very largely? Is it not just plain common sense to think so?

If this is true, then is it not true also that the use of films in poor mechanical condition—their retention in service after the time has passed when a screen image free from faults inherent in projection where old films are used—is an economic error? Do not you yourselves believe that the additional cost involved in the replacement of worn prints would be very much more than repaid at the combined box offices of the world?

Laying aside the fact that by intelligent procedure film exchanges could reduce the damage done to film by at least one half, let us see what it would look like in finance, admitting that our figures are designed only to let you see what might done on a relatively small advance in admission prices to theatres without any pretense of offering advice as to what admission price advance would be necessary to carry the added cost. There is a somewhat wide divergence of opinion as to the total number of theatres in the United States of America. It is stated variously at from 16,000 to 20,000, with the possible real number almost anywhere between. Supposing it to be 17,000, then, a five cent increase in admission to them all if their average attendance be 500 a day (surely a conservative figure) would amount to the somewhat amazing figure of $25.00 per day per theatre or 17,000×25 = $425,000 PER DAY increase in total revenue—surely quite sufficient to replace worn prints with new ones and leave a little over besides. And it is the "little over besides" which saves the situation, for, since there are a great many theatres already using film in excellent physical condition, which theatres could not, of course, be expected to increase their admission prices because of a thing which will only place the smaller theatres in better position to compete with them, it follows that the actual gain in total income, were all theatres now using more or less worn prints at reduced rental prices to increase their admissions by five cents per person would fall much short of the sum named. Surely, however, so enormous a sum as nearly half a million dollars a day is quite unnecessary to cover the cost of replacing old prints with new ones as soon as they are sufficiently damaged to appreciably detract from the beauty of the screen image.

While it is impossible for me to offer anything like accurate figures as to the probable total cost such renewals would entail, surely it is not at all unreasonable to presume that if all theatres now using prints which fall below the standard I am proposing to set up were to advance their admission prices in the sum of five cents per person, much more than ample funds would be provided to meet the advance in cost; it is not at all unreasonable to suppose that the necessary advance in admission price would be as great as this.

IS IT REASONABLE TO SUPPOSE THAT THE AVERAGE PATRON OF THEATRES NOW USING FILMS IN SUCH CONDITION THAT THE IMPERFECTIONS SHOW UPON THE SCREEN WOULD BE WILLING TO PAY AN ADDITIONAL FIVE CENTS ADMISSION TO HAVE THEM REMOVED AND VIEW A CLEAN, CLEAR FILM IMAGE INSTEAD OF THE DIRT COVERED, SCRATCHED, JUMPY THING HE NOW SEES? I believe the better show would be preferred at the advanced price even where the present admission is as low as ten cents, in which case the proposed advance would be fifty per cent. I firmly believe that the only real present day reason for the ten cent theatre is because those theatres use such imperfect prints (usually projected imperfectly too) that what the public sees on their screen does not seem worth more than that sum. Their goods are cheap goods, and the public, not being exactly fools, recognize them as such, and while it might not be willing to pay two or three times as much for a better show, it nevertheless would be willing to pay a reasonable advance—say five cents or less. With this I think you will either agree, or at least will not declare my argument to be altogether foolish.

That the substitution of perfect prints for the prints now used, which range through every stage from "they might be better" to just plain wretched junk, would be beneficial to the exhibitor under the conditions named seems certain. It is a cold fact that in many small town and village theatres the prints supplied are in such utterly wretched condition that the show which even a good projectionist could put on with them is not worth the small sum charged for admission, and those who go do so merely because there is absolutely no other amusement available. It seems absurd to suppose that these theatres would not be the gainer financially by such a change even with necessary advance in admission price,

That the exchange would be the gainer by handling only films in good physical condition does not seem open to adverse argument but it might be necessary for Film Boards of Trade to prevent a greater advance in rental price than just sufficient to cover the cost of the more frequent renewal of prints.

That the producer would be benefited by the sale of many more prints—well, that seems at least fairly evident.

I therefore submit to you the proposition that THE USEFUL LIFE OF FILM IS THE TIME BETWEEN ITS FIRST PROJECTION AND THE POINT AT WHICH THE SCREEN IMAGE IS APPRECIABLY AFFECTED BY DAMAGE INFLICTED UPON THE PRINTS DURING THE PROCESS OF PROJECTION OR OTHERWISE.

I submit to you the proposition that the retention of films, in service beyond the point where their damaged condition affects the screen image, merely because such prints may be rented cheaply is an economic error which reacts upon the industry and every one connected therewith to its serious injury.

I submit to you the proposition that the theatre using films in perfect physical condition will make more money in a year at admission prices enough higher to cover the cost of more frequent print replacements than will the theatre which, in precisely the same circumstances, uses films in poor physical condition at an admission price enough less to cover the difference as above set forth,

I submit to you, gentlemen, that if my contentions are correct in this matter, then the industry has been and is pursuing a policy with regard to the life of film which is totally at variance with good business procedure.

DISCUSSION

Mr. Denison: One must consider general conditions and in this case all the companies releasing pictures. Increasing the admission price to offset the rental fee would not help matters because the exhibitor would put the five cent increase in his pocket and insist on buying the film for the same price as before. If the operator or the projectionist would handle film as carefully as the exchange, the damage would be greatly reduced.

Dr. Gage: It seems to me that this whole question is one of business economics as to how improvement is to be made. In dealing with questions of improvement we must take into consideration the changeable factors. During this discussion one of the possible changeable factors has been brought up in the question of splicing machines, and another which Mr. Richardson has been continually talking about is the necessity for keeping the projectors in order. It occurs to me that the exchanges might offer a prize or some other sort of a premium to the exhibitors who possess and use the right kind of splicer, who see that the tension in the projector is maintained correctly, who see that the sprocket wheels are replaced as soon as they show wear and take care of other similar things. Of course, lastly and most important of all, some premium should be given to those houses who keep a really competent projectionist on the job all the time. I offer this as a suggestion on the economic situation.

Mr. Palmer: I believe also that this is an economic proposition, but I think it is the same as that of the Ford automobiles. There are a lot running about that Ford would not approve of. They are running because the men running them cannot afford anything better, and it is the same with the small exhibitors. They cannot afford to pay more for films, and the people who see them cannot afford to pay more.

Mr. Porter: Like the ugly duckling, I have been turning over in my mind for some time a little scheme for comment. I am not sure it is practical, but I should like to see what action I can start up. Possibly some plan might be worked out whereby with all the technical knowledge and business ability gathered together in this society we might find some means of taking over one of the smaller theatres and running it according to the best possible method that our combined information could scheme up. I believe the business of that theatre could be built up, its attendance increased, and its prices of admission increased and this done so economically and profitably. If the Society could do that as an experiment and keep careful and accurate data on it and publish that information for the benefit of thousands of other theatres of the same type, it might be worth while. Incidentally we might learn something—possibly, we might make some money out of it.

Mr. Brown: I think Mr. Porter's suggestion might perhaps be modified by suggesting that should the Society ever take over the theatre, they should take over the technical operation and make no attempt to take over those things which are properly dramatical. I do not think the Society could make a financial success of any theatre it took over and tried to run unless it limited itself to the mechanical excellence of projection and lighting. I have no doubt that one of the chains would be willing to give the Society the technical control of one of the very large and very conveniently situated theatre chains.

Mr. Faulkner: Dr. Sheppard, Mr. Denison, Mr. Richardson, Mr. Palmer, and also Mr. Cook were speaking as to what could be offered in the way of a cure for preventing the use of film in bad condition in the small town and neighborhood theatre. This has been solved in our own case. Famous Players have done what you say you would like to see done. Mr. Palmer says that the theatres show this poor grade of film because they cannot pay the higher prices; consequently, this is the class of film that they must expect. The instructions to our salesmen and to our exchange are that when a print is not fit to be run in the best-run neighborhood houses it is not fit to be run anywhere.

Every foot of film released by our company is returned to our department after it becomes obsolete through use or is worn out. This is for final disposition, and it comes back to use at the rate of about 2200 reels per week. It is examined by our receiving clerk or his assistants, and the physical condition of it is noted; if it is in a condition to be run and is a subject having playing value in another locality, it is salvaged. Out of the 2200 or 2300 reel we receive every week, fully eighty per cent of it is in good shape. We don't get back any that we should be ashamed to put in any theatre except for its scratched or oily condition. Shortage of footage or titles does not exist to any extent now.

In 1923, from our 40 offices in the United States, we had a total laboratory cost of reprints of close to $187,000. This wasreduced to under $20,000 for 1925 and is running about $1000 or $1200 per month up to the present time of this year, of which 75 or 80 per cent is coming from one or two offices. This in itself proves that we have reduced film damage.

When a subject is ready for release, the company arrives at an earning quota for that subject by figuring the cost of production, the cost of the number of prints required by our forty offices, the cost of distribution, etc., and from records can place a time on it when they can expect to get this money back, including with it the home office expense and dividends to the stockholders. A few years ago we were getting this back and all probable dates had been played out within two years' time. Since the inauguration of a department which makes it possible to speed this up by being able to book the film and play it so much faster, thereby playing more theatres in the same length of time, this period is considerably shortened.

Mr. Richardson: The film condition trouble has not been solved in the sense that Mr. Denison means. The condition of films sent by a large percentage of exchanges to the smaller theaters is very much worse than is generally realized. Famous Players do not have or handle that kind of theatre; hence, Mr. Denison's argument does not apply to the general situation.

While I grant that it is possible to so handle film that it may be used until the useful life of the subject it carries has to all intents and purposes ceased, it is impossible nevertheless to do so with projection equipment in the poor condition it is in, in many thousands of theatres in this country and Canada, and with projection equipment often in the hands of more or less incompetent men.

It was not my purpose, however, to argue these various details. This paper was not prepared—and I believe papers of this character are usually not prepared—because of the effect their reading to the meeting will have but because they will appear in our Transactions and there possibly will be read by producers, exchange managers, and theatre managers, to whom it is hoped this paper will show the foolishness of a procedure which keeps film in use until it is in wretched physical condition merely to cheapen the admission price to the theatres by what amounts to a trifle.

My whole argument is that, by an increase in film rental prices which might be covered by as small a raise in theatre admission as five cents per person, the films could be maintained in such condition that, aside from possible projection faults due to lack of knowledge of the projectionist, a good screen image could always be placed before all audiences.

TRICK PHOTOGRAPHY

Carl Louis Gregory*

THE MOVIES, our perennially infant industry, is no longer so infantile. Many of its first pewlings have already been engulfed in the oblivion of forgotten things. Trick photography was much employed in the production of the first French films. These were extensively "duped" in this country to feed the maw of the first Nickelodeons and store shows that have almost passed from memory. The first efforts of the various producers allied under the banner of the Patents Company made many similar films, some of which attained considerable popularity. "Dreams of a Welch Rarebit Fiend," "A Trip to Mars," "Alice in Wonderland," "Princess Nicotine," "The Yarn of the Nancy Bell," "The Absent Minded Professor," and "The Star of Bethlehem" are names of some of the old trick films made in America that may recall ancient history to the minds of some of my older listeners.

All of the productions named except the "Star of Bethlehem" were frankly trick pictures in which fantastic scenes, contrary to the laws of nature, were shown to obtain humorous and mystifying effects. "Dreams of a Welch Rarebit Fiend" was directed and photographed by Edwin S. Porter; "Princess Nicotine," by Albert E. Smith; and the others were photographed by me for the Edison and Thanhauser Companies, so that I feel qualified to refer to the dim but not so distant past.

Unlike the frankly fantastic subjects, "The Star of Bethlehem" was the "Ben Hur" of its day, when a thousand dollars spent on a production was more of an event that a million is at present. It was a conception of the birth of the Christ Child, and although its scenes were laid in Palestine and Egypt, the story was produced entirely in New York City and New Rochelle with only a few interiors set up in an old skating rink. The Wise Men of the East tended their flocks of sheep on the Mall in Central Park, and a piece of black cardboard masked out the tall buildings on 59th Street in the background. The Star of Bethlehem was later double exposed into the masked-out sky by means of a spot light photographed through a copper wire screen to give the shimmering rays which are

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shown in the conventional paintings which have been made to represent this sacred history. The massive walls of Fort Schuyler furnished the walls of the City of Jerusalem, and The Wise Men followed the Star on the backs of camels in the Bronx Zoo. Photographs of the pyramids were double exposed above a location on a sandy beach for the Sojourn in Egypt, and the pillared portico of a rich patent medicine manufacturer's residence served as the architecture of the Roman Court.

Since the days of these crude pictures, trick photography has waned and then waxed strong again. For a long time it was the step-child of the legitimate producers. The comedy producers, however, have always regarded it as one of their strongest allies. In fact, the credit for the present perfection of trick effects is largely due to the patient research of serious workers on the slap-stick lots. Far sighted producers have awakened to the money saving that may be effected by the use of trick photography, and now all the larger companies retain the services of high salaried experts who are specialists in the business of artistic photographic trickery.

Trick photography is a trick profession. It requires the arts of a trained magician with the added requirement that the spectator shall not even suspect that he is being deluded. Magicians must be familiar with psychology, with intricate mechanics, with physics, with art, with myriads of complicated details that must be made to dovetail to the fraction of a second. The craft of the ciné trick photographer is just as exacting and calls for an even wider application of special and practical knowledge.

It is not my intention to give in this paper any detailed explanation of trick photography. The subject is far too broad to be covered even in a large volume. Every piece of trick photography is a separate problem and just as the combinations of the alphabet are practically infinite so are the various combinations that may be arranged in doing work of this character.

Trick photography in cinematography is an analysis of motion in two or more directions. Simple ciné analysis of motion is the series of frames or pictures the successive units of which represent phases of action at intervals of one sixteenth of a second. Most ciné tricks require that two or more of these analyses be synchronized on one film and at the same time matched or blended with one another so that the line of demarcation between the two or more combinations be imperceptible to the eye even after the image is enlarged several thousand times on the theatre screen.

In cases where the recording or taking interval of the combined components is the customary sixteen per second in each case, the combination is not such a complicated problem as the written explanation makes it appear. It is very intricate, however, when the component members of the combination have to be taken at different rates of speed. In the "Lost World," there were many scenes where the taking of the action of the prehistoric monsters required weeks and months of exposures made at comparatively long and irregular intervals. These stop motion exposures had to be synchronized and combined with the action of human characters whose movements, photographed at regular speed, occurred in a few seconds, so that the composite result appeared to be simultaneous action. Not only was it necessary to synchronize the action, but it was also necessary to reverse the apparent size of the objects so that the monsters, which were in reality miniature figures, seemed to be gigantic in comparison with the human actors.

In the scenes showing the parting of the Red Sea in Cecil De Mille's "Ten Commandments" the action of the water was taken backward at a rate of several hundred exposures per second and synchronized with the action of the actors taken forward at the normal rate, while at the same time the relation in size was reversed and magnified.

Trick photography of this character is tremendously expensive, and yet the expenditure is justified, for it enables the producer to introduce scenes which he could not otherwise use either because they are physically impossible or because the expense of staging such scenes is financially prohibitive.

Trick photography thus does two tremendously important things for the industry; it renders possible the use of scenes and effects hitherto impossible of presentation and reduces enormously the cost of building elaborate sets. It also seems safe to prophesy that in the near future it will also eliminate the necessity for many exterior locations, particularly those at distant points where time and transportation are a large factor in production expense.

Let me outline roughly a sort of general classification of the various methods by which the trick photographer builds up his effects:

First, we have the basic standard of straight cinematography, which consist of a series of frames or pictures taken at the approximate speed of sixteen exposures per second.

Second, high speed or slow motion photography in which the taking rate is considerably increased. For the laws governing the taking of miniatures by high speed photography to simulate action in the tempo of natural sized objects, I refer you to the very excellent paper by J. A. Ball, entitled "Theory of Mechanical Miniatures in Cinematography" presented before the Society at Roscoe, New York, May 1924 and published in the Transactions of the Society.

Third, time condensation or decreasing the taking speed to such an extent that movements which take place slowly and over so long a period of time as to be imperceptible to the human eye are made to appear to occur in a few seconds. This method is commonly used for showing the growth of plants, the germination of seed, the erection or demolition of structures, etc. Slow cranking at slightly diminished speed is used to increase the speed of actors' movements for comedy effects and to speed up action in fights, races, and dramatic climaxes.

Fourth, trick crank or one picture one turn. This is closely related to time condensation. The trick crank shaft is the one usually used for making time condensation exposures. The name "trick crank" comes down from the early days of cinematography because the single exposure shaft was often employed in making many of the trick effects mentioned at the beginning of this paper.

Animated cartoons and diagrams are made by means of the crank and are, of course, trick photography. Nevertheless, in ciné nomenclature animated diagrams and cartoons are a classification separate from that of trick photography and, while most devices used by the animated cartoonist are used also in trick photography, the subject is too large to be treated in this paper. I refer those interested in the subject to the paper presented at this meeting by J. A. Norling on "Some New Developments in the Production of Animated Drawings "and to the very able volume by E. G. Lutz, entitled "Animated Cartoons," published by Scribners.

The difference between time condensation and trick crank work is in the interval timing. In time condensation, the interval between exposures is regular and in trick crank work irregular. In time condensation the exposure interval is pre-determined by the length of time in which it is expedient to show the resulting film. In trick crank work the successive phases of movement are artificially produced between exposure intervals so that inanimate objects may appear to be endowed with automotive powers. The time of exposure interval is therefore dependent on the time necessary to arrange the subjects in the successive phases of simulated action.

The prehistoric monsters in the "Lost World" were simply jointed models. Every move of every joint and limb had to be thought out beforehand as well as calculation made of the amount of movement which would occur in each succeeding phase of one sixteenth of a second if the model were an actual animal with the bulk and ponderosity of several elephants.

Fifth, "reverse camera," or the showing of the series pictures of a motion analysis in reverse order. The effects produced by this method are too well known to describe them.

Sixth, simple devices or attachments used mainly to alter the size and shape of the screen opening. These consist of masks or mattes of opaque or translucent material which either vignette the edges of the picture or produce silhouetted openings to enhance the illusion of scenes which are supposed to be observed through an archway, a keyhole, a telescope, binoculars, or other familiar orifices. Previous papers presented before the Society describe these devices in detail.

Seventh, "stop camera and substitute", which is one of the oldest and most familiar of trick devices. It was and is used mainly for magic appearances and disappearances. It consists in stopping the action and camera simultaneously and placing or removing the objects which are to appear or disappear. This was effectively used by Douglas Fairbanks in the production of the magic army in the "Thief of Bagdad."

Eighth, "the fade and dissolve." This is similar to stop camera but is a gradual instead of an abrupt change. It is produced by diminishing the exposure to zero and then running the film back to the commencement of the reduced exposure and fading in or increasing the second exposure at the same rate as the previous one was reduced, thus giving full exposure to objects which remained in the scene during the fade in and out, but gradually introducing or extinguishing the image undergoing the magical change.

Ninth, double or multiple exposure. By this device dual rôles can be played by a single actor. It consists of masking off a portion of the picture frame and making one exposure, then winding the film back to the beginning, and masking the first exposure while the second one is made on the remaining unexposed portion of the frame. The frame may be divided in this manner as many times as is necessary to produce the effects desired. I have made multiple exposures where the film was run through the camera twenty-six times. Dual rôles, visions, and ghostly apparitions are produced by this method. Masks are not usually used for ghost effects. The first exposure without the ghost is made in the normal manner, and the ghost, dressed in light colored clothing is exposed over the first record by posing the ghost actor against a black drop or shadow box. The details of the first exposure register through the shadows of the ghost outline and give it the shadowy or spiritual quality which ghosts are supposed to possess. The chief difficulties in double exposure work are in the synchronization of action and the matching of blending of the edges of the masked sections so that the line of demarcation is indistinguishable.

Tenth, glass work, which is a variety of simultaneous double exposure. The term "glass work" originated because the first examples of this work were accomplished by painting portions of scenes on plate glass. A piece of plate glass a little larger than the field of view of the lens at 10 or 12 feet from the camera is placed in a rigid frame parallel to the front of the camera. The field of action as viewed by the camera lens is left clear, and no painting is done on this portion of the glass. Any section of the remaining portion of the picture composition, however, can be masked out and replaced by a painting in accordance with the laws of perspective, of any kind of background or foreground that the production may require, With the use of this device it is necessary to build only such portions of a set as are required to form a background for the action, while the remaining portion is supplied by the painting on the glass. These pieces of glass work are called "cheaters" in the movie studios. Hardly any better term could be devised for these pieces of glass on which the "enormous" sets are painted, for they are cheaters in every sense of the word, and the cheating is tremendously effective.

When gazing at a vast and beautiful castle with serrated battlements or a lofty cathedral interior as shown on the screen, don't imagine that it has been built from top to bottom of wood and plaster. The actual set is often only ten or twelve feet high, and everything above that is painted on glass or beaver board.

The ordinary two inch ciné objective lens at distances beyond ten feet is almost universal in focus. This brings the entire picture in focus and does not blur the painting even though it is close to the lens and the set is far away.

A painted cheater can be used from only one viewpoint and by one camera. By use of miniature models built to scale, almost any number of different set ups may be made, but extreme care must be used in lining up the model with the actual set which it completes. In the "Hunch Back of Notre Dame," the picture shows a full size reproduction of the Cathedral of Notre Dame in Paris, and yet the actual construction of the set was only to the top of the entrance doors, the upper portion being supplied by glass work and miniature models.

Eleventh, simultaneous double exposure by means of mirrors and prisms. This is a reversal of the means by which two identical images may be superimposed and photographed on the same frame simultaneously, and as the two images may be independently focused, much smaller models and paintings may be utilized than in the glass work process. It is even possible to use a motion picture taken previously for the background of the new composite, so that actors in the studio may be shown amid the waving palms of a background photographed in the Sahara desert. This method has lately been heralded as a wonderful German invention under the name of the "Schuefftan" process but is antedated by several American users, among whom are David Horsely, J. Searle Dawley, and myself.

Twelfth, "double printing," which consists of making a composite negative by duping from two or more specially prepared positives and using masking devices in the printer, or in making a special positive from two or more negatives and then duping the result. This corresponds in principle to multiple exposure in the camera. It is usually used to superimpose dark images on high lighted areas, a thing which is difficult to do in the camera.

Thirteenth, "the traveling matte." By this process figures in action may be superimposed against any background without the necessity of building any sets at all. It requires very accurate mechanism to work it and is patented. It is sometimes called the Williams process from the name of the patentee, Frank Williams. It consists in photographing the action against a white background. By over exposure and intensification, a silhouette of the action is printed, leaving the background transparent. This silhouette forms a mask or traveling matte which is interposed between the printing light and the background negative while a print is made from it. This positive film is then run through the printing machine a second time in register with the action negative, thus printing in the details of the acting figures. From this double print a dupe negative is made for further printing. The silhouette print masks the place occupied by the action figures, and the original action negative has a dense black ground which masks the background negative image when making the master positive.

Fourteenth, "projection printing with separate positive and negative control." In this process the printing is not done by contact, as in the ordinary printing machine, but by projecting the image from the negative on to the positive. The movement of the negative and positive films is controlled by separate mechanisms, so that by manipulation of the controls any combination of the negative action series can be recorded in consecutive order on the positive film. The action on the original negative can thus be stopped, accelerated, retarded, or reversed on the positive, and by multiple masking and printing several successive phases of action on the same moving figure may be shown on the screen simultaneously. Max Fleischer and Alvin Kechtal are exponents of this process.

Fifteenth, mechanical devices operated independently and not connected mechanically with the operation of photography or printing have not been considered as coming within the province paper. They are too numerous even to attempt their listing. It should be said in this connection, however, that the trick photographer leaves no stone unturned in seeking to produce the desired effect, and any device which lends itself to his use is considered his legitimate ally.

DISCUSSION

Mr. Crabtree: Are semi-transparent mirrors used extensively?

Mr. Gregory: They were intended to be included under the use of prisms.

Mr. John G. Jones: How large were the miniature beasts shown in "The Lost World?"

Mr. Gregory: About three or four feet high.

Mr. Norling: What is the effect of taking pictures when using the cheaters at different times of the day?

Mr. Capstaff: Are the cheaters done by free hand or prepared by photography?

Mr. Richardson: I do not understand how the little twigs which we saw in the motion picture miniature the other night are made to look like huge logs.

Mr. Gregory: In photographing action in miniature, it occurs in a much shorter period of time than with full size objects. An object falls sixteen feet the first second; if dropped only a short way, the action occurs in a fraction of a second, but if you speed up the high speed camera in taking so that as many frames are taken of the miniature as is required for the simulated distance at the ordinary rate, the appearance is natural on the screen.

With regard to the cheaters at various times of day: they have to be painted for the time of day when the light will fall so that the shadows match. This is always done beforehand, and the lighting must always be considered.

Photographs are used but not so much as they could be, I believe. Generally, it entails the use of more photographic equipment of a special kind than there is in the studio, and they have to match them up, so that it is easier to employ an expert painter to get the exact perspective and dimensions and everything to the fraction of an inch than it is to employ a photograph. However, transparencies are sometimes used but not as often as you might think. It is necessary to make either an accurate floor plan of the set or, as is more often done, the camera and glass plate are set up in position, rigidly fixed, and the painting is done after this preparation so that the continuation of every column matches to the fraction of an inch as well as the shading of the light, and so forth.

Mr. Palmer: I happen to know something about this cheater work, and I might say in answer to Mr. Norling about lighting by daylight that when we make these, although we do them outdoors, we use artificial light and in this way keep the light uniform.

With regard to using photographs. It would be possible to take one frame of the picture and enlarge it on the sheet of glass, but you must paint the photograph afterwards in tones corresponding to the tones in the set itself. You might therefore just as well paint it in the first place.

Mr. Capstaff: I thought you might make a photographic enlargement on paper and use it as a basis for the artist to work up. You could then put in any scene having detail and half tone.

Mr. Gregory: Very large enlargements are used to a great extent, more particularly on the coast. They must be touched up to come up to the required contrast of the lighting. They are usually used for window and door backings.

THE STAINING PROPERTIES OF MOTION PICTURE DEVELOPERS*

J. I. Crabtree and M. L. Dundon

When most developing agents become oxidized either by the oxygen in the air or by virtue of performing useful work in reducing a silver emulsion to metallic silver, they are converted to colored products which behave like a solution of a dye towards the gelatin coating on film and stain it uniformly. With developers like pyro, which in alkaline solution readily oxidizes to a reddish brown compound, more or less of the colored oxidation product is deposited along with the silver image during development so that a stain image is obtained. This image increases the effective contrast of the negative but is usually accompanied by more or less general stain.[1] Elon and hydroquinone oxidize much less readily than pyro, and in the case of an average elon-hydroquinone motion picture developer which contains a relatively high concentration of sulphite, the rate of oxidation is comparatively slow. The oxidation products of the hydroquinone in this case are most probably hydroquinone mono and di-sodium sulphonates[2] which are colorless. The mono-sulphonate is a weak developer and the di-sulphonate does not develop at all. This explains why certain elon-hydroquinone developers on standing in an open tray for two or three days at room temperature may lose their developing power although they become only slightly colored.

On standing in a storage vessel without use, the average positive or negative developer turns brown, but the concentration of oxidation products formed is very rarely sufficient to appreciably stain film which is developed in it, and in any case the slight stain produced in the developer is usually destroyed or decolorized in the acid fixing bath. With use, however, an elon-hydroquinone motion picture developer discolors more rapidly than can be accounted for by the formation of oxidation products, and the bath grad-

* Communication No. 271 from the Research Laboratory of the Eastman Kodak Co.

[1] "Stains on Negatives and Prints, Their Cause, Prevention, and Removal" by J. I. Crabtree, Amer. Ann. Phot. (1921) "Development Stain" by J. Southworth, B. J. Phot. *72*, 379, (1925)

[2] "Sulphite in Developers" by J. Pinnow, Phot. Rund. *60*, 27, (1923)

ually becomes opalescent. This opalescence is a result of the accumulation of colloidal metallic silver formed by reduction of the silver halide dissolved out of the emulsion by the sulphite in the developer.[3] In case the rack system of development is employed, the hypo carried over by the incompletely washed wooden racks also assists in dissolving the emulsion. Such a colored developer containing oxidation products and colloidal silver will, however, rarely cause staining of the film.

The presence of silver in the developer can be readily shown by adding a little potassium cyanide solution, which dissolves silver but does not affect the colored oxidation products. The addition of cyanide to an opalescent developer usually removes the opalescence. Any residual color is then due to developer oxidation products.

Facts which Led to this Investigation

The number of feet of film per unit volume which can be developed before discarding the developer is termed the "life" of the developer. In the case of two motion picture developers (Formula Nos. D-16 and D-11) used for developing positive motion picture film on wooden racks, it was observed that the life of the solutions was not so great as for previous batches of the same developers, because on prolonging development to secure high contrast the highlights of the film were invariably stained.

The formulae of the two developers used are as follows:

Normal Positive Developer
(Formula D-16)

	Metric		*Avoirdupois*	
Elon	0.3	grams	2	ozs.
Sodium sulphite (desiccated)	37.0	grams	16½	lbs.
Hydroquinone	6.0	grams	40	oz.
Sodium carbonate (desiccated)	18.75	grams	8	lbs.
Potassium bromide	0.9	grams	6	oz.
Citric acid	0.75	grams	5¼	oz.
Potassium bisulphite	1.5	grams	10	oz.
Water to make	1000.0	cc.	50	gal.

Contrast Positive Developer
(*Formula D-11*)

	Metric		*Avoirdupois*	
Elon	1.0	grams	7	oz.
Sodium sulphite (desiccated)	75.0	grams	33	lbs.
Hydroquinone	9.0	grams	4	lbs.
Sodium carbonate (desiccated)	25.0	grams	11	lbs.
Potassium bromide	5.0	grams	2¼	lbs.
Water to make	1000.0	cc.	50	gal.

[3] "On the Formation of Colloidal Silver in Photographic Developers" by L. Lobel, Bull. Soc. Fr. Phot. *60*, p. 21, (1920)

Careful examination revealed that the stain deposit was of the nature of dichroic fog although it had a more metallic appearance, and on prolonged development it was possible to secure perfect silver mirror deposits on the gelatin surface of the film.

It was observed that the trouble did not occur as long as the developer was opalescent; that is, if it contained colloidal silver in suspension. The opalescence would frequently disappear if the developer was allowed to stand without use for several days as a result of coagulation of the colloidal silver suspension, and in this condition the developer was apt to give silver stain. In some cases the developer never became opalescent, and such non-opalescent developers and likewise those in which the opalescence disappeared on standing invariably gave stain with use; in other words, opalescence of the developer was an insurance against the formation of this type of developer stain.

Methods of Destroying the Staining Tendency of the Developer

At the outset, the exact reason for the formation of the stain was not known, but attempts were made to revive a staining developer by the addition of various chemicals. The addition of potassium bromide and potassium iodide reduced the quantity of stain formed, but it was necessary to add such a quantity of these substances that the rate of development was retarded excessively. Boiling the developer in some cases completely removed the staining tendency, while in other cases this treatment was only partially effective.

The addition of potassium cyanide and potassium sulphocyanide in sufficient quantity likewise prevented the stain but only when added in such a concentration that a reduction of the silver image occurred. The staining tendency was entirely prevented, however, by the addition of lead acetate or silver nitrate or by developing a quantity of film in the developer.

Methods of Producing Silver Stain with a Fresh Developer

At the outset it was erroneously considered that the stain was a result of precipitation on the film of the colloidal silver suspended in an opalescent developer. The fact that the stain was produced only by developers free from visible opalescence, however, disproved this theory.

The fact that the stain was prevented by additions of lead acetate or silver nitrate suggested that the presence of sodium sulphide in the developer was in some way responsible for the stain. In a previous paper[4] it was shown that under certain conditions sulphide forming bacteria or fungi grow in a developer and reduce the sulphite, sulphates, or hypo present to sodium sulphide, which causes fog. It is also known that the presence of silver solvents in a developer tends to cause dichroic fog[5] and an old motion picture developer is liable to contain traces of hypo because of the difficulty of thoroughly eliminating the hypo from the wooden racks during washing.

The addition of hypo in quantities varying from 0.05 to 0.22 per cent to either a fresh developer (D-16) or one which was partially exhausted did not cause stain with positive motion picture film. Also, when traces of sodium sulphide were added, only black silver fog was produced.

If a trace of sodium sulphide was added together with the hypo, silver stain was invariably produced. The concentration of the sulphide was varied from 0.01 to 0.1 per cent and that of the hypo from 0.05 to 0.2 per cent. The mixture giving stain which most nearly resembled that obtained with the exhausted developers tested was obtained by adding 0.08 per cent hypo and 0.05 per cent sodium sulphide.

The stain was likewise produced by substituting ammonia for the hypo in the presence of sodium sulphide, showing that the essential impurities necessary to produce stain were sodium sulphide and a silver halide solvent.

Successive treatment in an 0.05 per cent solution of sodium sulphide followed by development in a developer containing 0.08 per cent hypo gave only black development fog, but by reversing the treatment; namely, immersion of the film in an 0.08 per cent solution of hypo followed by development in a developer containing 0.05 per cent sodium sulphide, the mirror-like dichroic fog was produced.

Tests for the Presence of Sulphide and Hypo in the Developer

A sample of developer which gave bad silver stain was tested for the presence of sodium sulphide by placing a strip of filter paper saturated with a 10 per cent solution of lead acetate in the neck

[4] "Sulphide Fog by Bacteria in Motion Picture Developers" Merle L. Dundon and J. I. Crabtree, Trans. Soc. M. P. Eng. No. 19, p. 28, (1924)

[5] "Dichroic Fog" by Lumière and Seyewetz, Phot. Journ. *43*, 223, (1903) "Photographische Probleme" by Luppo-Cramer, Knapp Halle

of the bottle just above the surface of the developer. The acetate paper turned black, showing the presence of sulphide. Lead acetate added directly to the developer also formed a black precipitate, indicating the presence of sulphide. Several days later the test was repeated, but no indication of the presence of sulphide was obtained. Also a test strip developed in the developer showed no signs of silver stain.

This observation may be explained by the fact that the sulphide forming bacteria are anaerobic and are destroyed in the presence of air. The developer at the bottom of a deep tank as used in motion picture work does not come into contact with air, so that the bacteria can thrive. If such a developer is stored in a partially filled bottle, the conditions for bacterial growth are then aerobic and the sulphide forming bacteria are killed. The sulphide already present is also oxidized.

The authors were unable to devise a satisfactory test for determining the concentration of hypo in the developer. The probable hypo content was arrived at indirectly by soaking the dried wooden racks after they had been in use for several weeks in a tank of water of the same capacity as the developer tank and then estimating the quantity of reducing agent present in the water. In terms of hypo it was calculated that when the developer was half exhausted, the concentration of hypo was about 0.1 per cent. This figure is very approximate, because more or less sulphite and other reduceable substances would be extracted from the wooden rack, but in the calculation only one-half of this was assumed to be hypo.

The Relation Between Sulphide Fog and Silver Stain

From the fact that the presence of both sodium sulphide and a more powerful silver solvent than sodium sulphite is necessary in a developer to produce silver stain, it is probable that the sodium sulphide first precipitates minute particles of silver sulphide on the surface of the emulsion, and these in turn act as nuclei for physical development. A physical developer consists of a mixture of a solution of a silver salt and a reducing agent capable of reducing this to metallic silver, and such a combination is present in most developers by virtue of the reducing agent (elon and hydroquinone) and the silver halide dissolved by the sulphite and hypo present in the developer.

The effect of potassium iodide in retarding the formation of the silver stain is probably a result of the conversion of the silver bromide grains in the emulsion to silver iodide, which is less soluble in the hypo, so that physical development is retarded.

The addition of lead acetate or silver nitrate to the developer removed the sulphide, leaving only hypo, which alone does not produce fog or stain in the concentration under consideration.

The effect of boiling in removing the staining tendency of the developer is somewhat obscure. This probably caused removal of the sulphide by more complete interaction with particles of emulsion suspended in the developer which were removed mechanically from the film during handling.

The observation that the staining tendency was reduced if the developer was used continuously and not intermittently is explained by the fact that the sulphide is precipitated by the silver dissolved from the emulsion.

Sulphide fog, as previously described, is most probably ordinary black fog caused by conversion of the unexposed grains of the emulsion to the developable condition by the sodium sulphide, At the time of the first discovery of sulphide fog in motion picture developers, the effect was noticed with only negative developers. The fog appeared as excessive ordinary black silver fog in the normal time of development. A few months later the silver stain was noticed in comparatively fresh positive developers on prolonged development. As the developer became older, the silver stain appeared with lower degrees of development until finally the stain appeared with normal development of 4 to 5 minutes at 65° F., when it was necessary to discard the developer. At this stage the developer had processed only from one-quarter to one-half the normal quantity of film. So far as could be observed, in the case of positive film, which has a much finer grain than negative film, the fog was always colored yellowish brown by transmitted light and had a metallic looking sheen.

In order to test the nature of ordinary sulphide fog as compared with silver stain fog, strips of positive motion picture film were developed for 5 minutes at 65° F. in the normal positive developer (D-16) containing 0.01 per cent hypo. With the addition of sulphide, a black deposit of fog was obtained having a density of 0.7, while with the mixture of sulphide and hypo a yellowish fog with a metallic sheen having a similar density was obtained.

Although no satisfactory test for differentiating between fine grained deposits of silver and silver sulphide is known, metallic silver grains are readily attacked by a mixture containing 1 per cent potassium ferricyanide and 1 per cent potassium bromide, while those of silver sulphide are not so readily attacked. On applying this test, both the silver stain and sulphide fog deposits were attacked, but the former less readily than the latter.

From these tests it is apparent, therefore, that silver stain consists largely of silver with probably some silver sulphide, while ordinary sulphide fog in the absence of hypo consists largely of metallic silver.

The yellow appearance of the silver stain by transmitted light is due to the small size of the silver grains constituting the deposit and also to the yellow color of any silver sulphide present. The effect of the addition of hypo to the sulphiding bath when toning transparencies by the sulphide method in producing yellowish tones is well known.

No silver stain has been encountered in practice when developing negative film. This is no doubt because of the relative coarseness of the silver halide grains of the negative emulsion and their relatively lower solubility in the hypo present. Also, ordinary black sulphide fog has not been encountered when developing positive film by the tank system because accumulated hypo was always present along with the sulphide. Black sulphide fog, however, has been encountered with positive film in the case of a developer used in a processing machine when there was no possibility of access of hypo to the developer. A black sludge of silver sulphide invariably settled out of such a fogging developer.

No silver stain has been encountered with processing machines because of the impossibility of access of hypo to the developer.

Methods of Preventing the Formation of Silver Stain

The cause of silver stain being known, methods of prevention involve the prevention of the formation of sodium sulphide and the accumulation of hypo in the developer.

Prevention of Sulphide Formation.

At the present time no method is known for preventing the growth of sulphide forming bacteria and fungi in a developer once it has become inoculated. It is important to prevent their access in the first place.

It was invariably noticed that a slime was present on the sides of the tank containing the staining developers, and it was assumed that this contained the bacterial colonies. The experiment was tried of thoroughly scrubbing the empty tank with a solution of sodium hypochlorite or bleaching powder and then thoroughly washing before refilling with developer. This prevented the formation of the silver stain even though the racks used were not waterproofed and therefore carried more or less hypo into the developer.

Prevention of Hypo Accumulation

Wooden racks of cypress or spruce as ordinarily employed absorb a relatively large quantity of water and likewise hypo solution. The rate of removal of this hypo by the wash water is relatively slow in the case of racks having large diameter slats for the prevention of rack marks especially at the points of contact of the film with the rack. The obvious solution of the problem was to waterproof the racks thoroughly so as to prevent access of the hypo to the pores of the wood.

The most satisfactory method of waterproofing wooden racks is to impregnate the wood with paraffin wax. Painting, lacquering, or treatment with a solution of wax in a suitable solvent is not effective. Lacquer or paint chips off, while treatment with the wax solution leaves an excess of paraffin on the surface of the slats which is liable to be scraped off by the film and adhere to the emulsion.

The racks may be satisfactorily impregnated with paraffin by first thoroughly soaking in water and then immersing in very hot paraffin wax. The soaking serves to swell the wood, and in the hot paraffin bath the water in the pores is replaced by paraffin. The racks should be thoroughly wiped with a cloth on removing from the paraffin bath to remove the excess wax. No trouble has been encountered when using such paraffined racks.

Removal of Silver Stain

It was possible to remove slight silver stain deposits by careful treatment with dilute solutions of the usual silver solvents, such as potassium cyanide, without attacking the image. It was found more satisfactory, however, to treat the film with a solution of neutral potassium permanganate, which converts colloidal silver to silver oxide but attacks the ordinary silver image very slightly.[7] The exact procedure was as follows:

The film was first hardened in a 5% solution of formalin, washed, and treated for 5 minutes in a 5% solution of neutral potassium permanganate. After washing, the film was fixed in a 30% solution of plain hypo for 5 minutes and then cleared in a 5% solution of sodium bisulphite, washed, and dried.

Summary

When developing positive motion picture film by the rack and tank systems it is frequently necessary on account of the formation of stain to discard a developer which is otherwise satisfactory. This stain is usually in the nature of dichroic fog having a metallic silvery appearance and is not oxidation stain, since the quantity of sulphite in the average elon-hydroquinone developer is sufficient to prevent the accumulation of staining oxidation products.

It has been shown that the silver stain is a result of the presence of both hypo and sodium sulphide in the developer. Hypo accumulates as a result of insufficient washing of the racks after fixing, while the sulphide is formed by the reduction of the sulphite and hypo present in the developer, by bacteria or fungi.

The remedy consists in using waterproof racks so as to prevent the transference of hypo, and in sterilizing the tanks before filling with developer.

Acknowledgement

The authors are indebted to Mr. V. J. Moyes and Mr. R. M Corbin for valuable assistance in the course of this work.

[6] "Rack Marks and Airbell Markings on Motion Picture Film" by J. I. Crabtree and C. E. Ives, Trans. S. M. P. E. No. 24, p. 95, (1926)

[7] "Dichroic Fog" by Lumière and Seyewetz, Camera, p. 381, (1924)

CLEANING MOTION PICTURE POSITIVE FILM

Trevor Faulkner

In CONNECTION with a department of my firm which is concerned with the distribution of positive film, I have been interested since very early days in the production of an efficient film cleaning machine. The machine which I am about to describe to you has been installed after much experiment and is one which very satisfactorily cleans and revitalizes dirty film.

That film should become soiled is in the nature of things. In practically all cases the projection booth is in the most remote part of the theatre, where it is seldom under the care of a janitor or porter, and in too many cases is hardly ever inspected by the manager. This means the periodical accumulation of dust and dirt till the operator is forced to have a "house cleaning." It is seldom that you will find the floor of a booth free from grit and oil, which is most harmful if the film has to be "spilled" to secure uninterrupted screen presentation during a minor accident.

Again, on account of the booth being at the highest point of a theatre, and usually with an exhaust fan in it, most of the dust that arises from the constant stir of patronage is drawn into the booth and necessarily through the port holes in front of the projection machines. So much for the conditions supplying dirt.

Now let us consider our stock or ware and its handling. When positive film is first released, it is more sensitive to damage than when older, and consequently more care must be used in its handling, Regardless of any prior waxing the film may have had, to prevent this probable damage the "operator" often applies oil to the film. Then, there have been cases known where the unfortunate film runs through a continuous bath of lubricating oil. In one make of a projection machine, when the projector is tilted to fit the angle at which the light rays must be thrown to reach the screen, there is a receptable created at the base of the mechanism that is capable of receiving and holding a sufficient amount of drainage oil to give a long lower loop a steady bath. Sometimes the film gets a constant spray or sprinkle of oil through a worn intermittent bearing. It is also customary for the operator to have a pan placed on the floor under the projector to catch the oil drip from the mechanism, and often this pan, with more or less oil in it, will also catch the ends of the film as the operator is either threading up the machine or is taking the film out of the lower magazine. You can rightfully place the blame for oil on film to one or all of these conditions, for in no other way does film ever come in contact with oil.

Motion picture film in its rapid passage through the machine may become charged by friction with static electricity which will enable it to attract and attach any dust in its vicinity. Consequently when the doors of an enclosed projector are opened or when the film is "spilled" it becomes plentifully coated with lint and dirt which it annexes permanently if there is any oil to act as a cement. Further passages through the projector rolls the mixture in until a very objectionable layer coats both emulsion and base.

The projectionist is quite aware that a fine sparkling picture can only be produced from clean film; nevertheless, in too many cases the presentation is marred because he has no equipment for securing this cleanliness.

In considering cleaning machines, we have had in mind the importance of the wash fluid which is actually to do the work. It must be non-inflamable, give off no explosive or poisonous gases, and be free from any acids or alkalis that might attack the silver image, and furthermore it must be cheap. We have been fortunate enough to secure such a solution and are using it daily in our department with very satisfactory results.

At this stage we were able to enlist the co-operation of the manufacturer then making the best machine on the market. He agreed over an extended period to exploit certain of our ideas and make any changes necessary to carry them out. We are pleased to say that the experiments have resulted in a cleaning machine which really does the required work quickly and inexpensively. We find that our operators can clean twelve to fifteen reels an hour. As they come off the machine, they are handed to the inspector, the reel bands are placed in position, and the work is ready to be placed in the vaults. The output is thus about one hundred reels a day per unit.

Figures 1 and 2 show the actual machine, which is made by the Dworsky Film Machine Corporation, 520 West 48th St., New York City. The film is first passed through a bath of the wash solution, contained in a trough *A*, about eight inches being submerged at a time. Felt brushes submerged in the liquid brush both sides of the film. The film then travels up through a series of four rubber wipers at *B* suspended on a spring suspension at the same

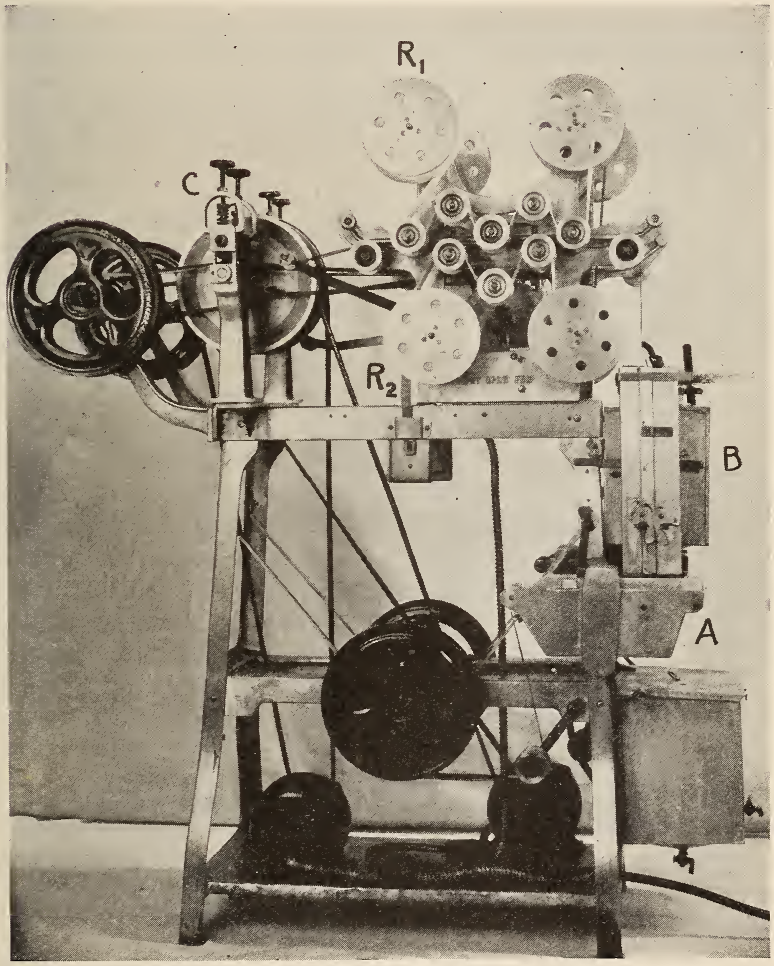

FIG. 1. Film cleaning machine.

angle, which wipe the film very much in the manner that a window cleaning "squeegee" wipes the water from a freshly washed window pane. The film then passes between flannel strips fed from reels

R1 and *R2* and slowly driven in an opposite direction to that in which the film is traveling. The points of contact with these strips are arranged at offsetting points, so that the tension of the film is sufficient to polish it thoroughly on both sides. The film then passes through two rubber rollers at *C*, which simply pull the film through the machine. The film is then wound on a reel by an automatic take-up similar to the take-up on the lower magazine of a projection machine. The entire operation requires about 4½ minutes to the thousand foot reel of film.

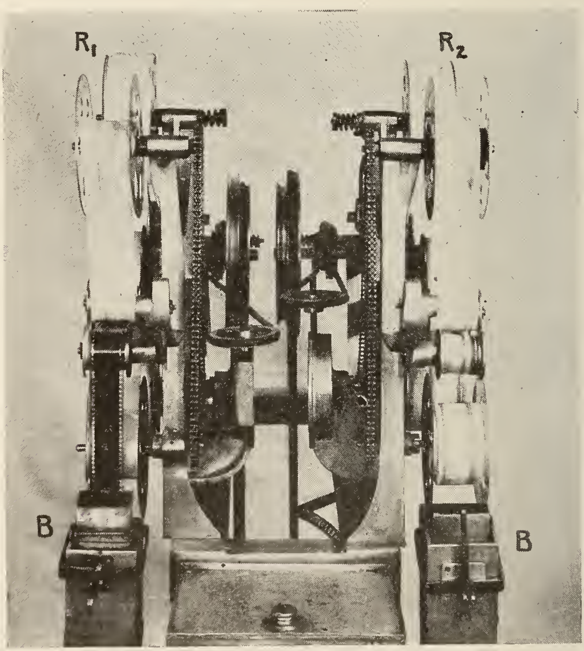

Fig. 2. Film cleaning machine, showing squeegees and wiping felt.

The solution tank holds approximately one quart of the cleaning fluid, which is drained off into a filter after every seventh or eighth reel. After passing through the filter, the fluid can be used as often as it is thoroughly filtered and freed from the dirt that it carries after it has cleaned the seven or eight reels. By actual measurements, this filter from a day's work of one hundred reels of film has caught 14 cubic inches of dirt.

I will repeat that the hopes of ultimately having available a satisfactory plant for cleaning film has been the goal toward which I have been striving for years. During these years of what you might classify as research there have been many machines considered and tested, many wash solutions analyzed, and every system with which we could come in contact investigated. Many of them have merit, and almost all of them offer in some manner a remedy for dirty film. In most instances, the plants that were investigated were operated by their owners as cleaning plants, and their business was confined to cleaning film and not to selling equipment for film cleaning. In such cases it meant the loss of time to transport film to and from our plant to theirs. This research work included a very careful study of various types of machines which were on the market and recommended for exchange use but which we found after a very careful analysis did not accomplish the result we desired.

In analyzing a machine, it is necessary to take into consideration the following pertinent factors:

First, in developing capacity, you must bear in mind the greater the speed of operation, the greater the possibilities of film damage. We have minimized damage by using large aluminum rollers with wide flanges to guide the film and by the elimination of sprockets. A gravity switch controls the motor so that, should the film break, the machine is stopped immediately. There are no buffs or fast rotating polishers to heat the film should it become stationary, and there are no sprocket teeth to injure it, or idler rollers to crease or mark it.

To summarize: We are now cleaning film, regardless of the amount of oil and dirt that there is on it at the rate of a one thousand foot reel in practically five minutes. Every inch of the one thousand foot reel is entirely free from all oil and dirt; there has been no strain on the perforations in any manner; both sides of the film are polished; and this without shrinkage or damage to the tinting.

We may safely claim that film which has received such treatment is so smoothly polished on either side that, besides being clean and transparent, it is able to pass through the projector with the least possible friction and damage to itself.

DISCUSSION

Dr. Hickman: The point that interested me was not the mechanical apparatus but the cleaning fluid, the composition of which was not mentioned. I should like to make one or two general remarks on cleaning fluids. There are a number of liquids which remove dirt and oil but have no solvent action on the emulsion or base; perhaps the best known are carbon tetrachloride and light petroleum. Various commercial chlorine derivatives of ethylene and acetylene can be used, but undoubtedly the most important is carbon tetrachloride. Though it is superior to benzene and petroleum in being non-inflammable, it behaves as a specific poison for certain people. Some years ago in England it was used as a hair wash until one day a lady was carried out dead after a shampoo, which sad accident caused it to be prohibited by law. Its toxic properties are increased if it is kept in transparent bottles in full window light, probably owing to oxidation and development of phosgenes.

I have found a mixture of equal parts of the tetrachloride and light mineral naphtha excellent for cleaning purposes. It is scarcely inflammable, burns only under strong provocation, and then with such a sooty flame that it is instantly noticed. It is cheaper and not so harmfully affected by light.

I should like to ask the speaker how he manages to make his solvent work over and over again with no treatment but filtering. If the liquid dissolves oil, the oil will remain behind when the mechanical dirt is strained away and will accumulate till it is in equilibrium with that carried out by the scrubbed film. Part of the oil will be deposited on the rubbing wheels; the remainder will be distributed in a microscopic coating on the film surface. Here it will doubtless do good rather than harm, but it would be more correct to say that the solvent had effected redistribution than removal. Complete removal is only possible where distillation of the solvent is substituted for filtering.

Mr. Crabtree: I might add to Dr. Hickman's remarks by saying that commercial samples of carbon tetrachloride are apt to contain sulphur chloride, which will eventually attack the silver image and cause it to fade, especially in damp atmospheres. Purified carbon tetrachloride is now on the market; it is a product from which the sulphur chloride has been removed and is quite satisfactory. I suggest that if you buy this you should specify that it be free from sulphur chloride to ensure against its affecting the silver image.

Mr. Joy: I should like to ask if I understood correctly that application of the solution restored the flexibility of the base.

Mr. Faulkner: Our tests indicate that the flexibility is improved, but this may be largely a result of the absorption of moisture.

Mr. Joy: But it doesn't always get a chance to take up water.

Mr. Faulkner: In reply to Mr. Crabtree, we do not use carbon tetrachloride but trichlorethylene.

Mr. Crabtree: My remarks apply equally to most chlorine substitution products. In the presence of moisture many of these cause the silver image to fade. Purified tetrachloride is about the most satisfactory solvent for oil on film.

MOTION PICTURE THEATRE PROGRESS IN SMALLER TOWNS AND RURAL COMMUNITIES

Harry E. Holquist*

LESS THAN two years ago, leading theatre architects in answer to a survey on the subject expressed it as their belief that the motion picture theatre had reached its maximum size in the 5,000 seat house. Today, we have in course of construction the new Roxy Theatre in New York which will seat 6,200, and there are now those who predict that a cinema palace seating 10,000 is not at all an improbability of the future. Theatres of 4,000 seats are becoming comparatively common when we consider how few houses of this size there were three years ago. Beautiful playhouses of a capacity from 2,000 up have been erected on an unprecedented scale in the metropolitan centers in the past few years.

Very pronounced and very remarkable progress has been made in the construction and design of these theatres costing millions of dollars. As places of public gathering, they represent the finest types of public buildings in the country. Their beauty of decoration, furnishings, and lighting have dazzled the public. In them, has been incorporated every element making for safety and comfort. We of this industry can point with justifiable pride to these monuments to the youngest of the arts.

However, in our proximity to these mighty and beautiful edifices I believe many of us have failed to visualize the complete picture of the remarkable progress that is being made and will continue to be made in theatre construction in smaller towns and rural communities. In these localities motion picture theatre history is being made as surely as it is in the larger cities. Here lies a great field and a wonderful opportunity for development and promotion of a type of building that will place the motion picture theatre universally on a new high level both artistically and commercially. The surface of possibilities in this direction hardly has been scratched, although the progress that has been made to date is highly encouraging and reveals opportunities which I believe to be of keenest interest to every one in this industry.

The new theatres in smaller towns being erected today are in the majority of instances the finest buildings in their respective

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communities. They represent investments up to several hundred thousand dollars, are modernly furnished and equipped, and are built for the years to come. This latter feature is significant. It means that in the countrywide replacement of earlier theatres which is taking place, exhibitors appreciate the fact that nothing less than the most modern type of building will offer them economic protection against growth, not to mention possible competition.

In a Wisconsin town of 10,000 population a certain exhibitor has just completed a theatre next to the town's leading bank. (By comparison the bank building looks like a machine shop alongside a skyscraper). This roughly exemplifies the new thought and trend in theatre construction in smaller cities. Obviously this exhibitor could get by with a theatre half as costly and much less impressive and modern. He is a veteran builder, however, and knows from experience that in erecting a theatre of the type he has done he is prepared to care for that community's amusement needs for a life time. Admitting inevitable improvements in the future, he is secure in the knowledge that his theatre is still so far superior to other structures in his community that it cannot possibly become antiquated until the investment has long been repaid.

I believe it will be of interest here to describe briefly a theatre which gives a perspective of the many improved features of the present day smaller theatres. This theatre is erected in a city of 30,000 population and seats 1,300. It is constructed of Indiana limestone with trimmings of variegated tapestry brick in buff color. The architectural scheme is the Old Roman style. The building is entirely fireproof construction, floors and stairways being of reinforced concrete. Its height is equivalent to four stories which, it will be recognized, makes it an outstanding structure in a town of this size. The exterior provides for an impressive marquee over the main entrance. Two small stores are provided at either side of the lobby. On the second and third floors are offices. Going into the theatre, we find that it has an attractive arched foyer. The floors are luxuriously carpeted. The walls and ceiling of the of the foyer are highly ornamental. The foyer has a vaulted ceiling offset by arches and leads into the main auditorium, where there is an effective system of cove lighting controlled by switchboard and dimmers. There is a picturesque dome recessed in the auditorium ceiling. A spacious cove stands out from this ceiling where it rests on a heavy ornamental cornice. Soft lights are everywhere casting shadows and high lights, bringing out the architectural beauty of the interior. The theatre is equipped with comfortable upholstered seats. There are retiring rooms attractively furnished for men and women. A modern cooling and ventilating system keeps the auditorium comfortable under all conditions. Stage facilities have been provided that care for all types of attractions, from home talent shows to the larger plays. Everything is neat, clean, and sanitary. Looking along the main street a large electric sign emblazons the theatre name. It is the brightest spot in town, and the building is found to be easily the most up-to-date structure along the street.

Such, briefly, is the type of theatre being built in smaller towns and rural communities in all sections of the country. It is as inspiring as any of our big metropolitan theatres, for it means that the power of the motion picture theatre is extending into all corners of the land.

The motion picture theatre in the smaller cities occupies an unusual place in civic life. Let us consider the case of two towns drawing business from an area midway between. Everything else being equal, the town which boasts the finest motion picture theatre is the one which will attract the greatest number of people to its gates. The business effect of this on all lines of local industry is readily appreciated. For this reason it is important to think of the small town and rural theatre as an important and influential unit of the community.

Regarded in this light the small town and rural theatre assumes new proportions of significance, becoming a dominant structure in moulding civic beauty and setting a pace for the artistic development of entire communities. Yet, there is much to be done by leaders in the construction and engineering field. J. H. Phillips, theatre architect of New York, in the Theatre Number of the Architectural Forum says:

> Our modern domestic architecture has made a steady and wonderful advance in recent years. Not only have housing conditions improved through careful study of the leading architects who have designed artistic houses, but also our public buildings, particularly our public schools, have become worthy examples of architecture. It is most unfortunate, therefore, considering the great number of theatres and motion picture houses that have been built in recent years, that architects have not given more attention and shown more creative ability in the designing of the small rural and suburban theatres. Here lies a great opportunity to improve public taste by designing more attractive buildings, which will attract and delight the public. An attractive, comfortable motion picture theatre in a suburban town is a source of pride to the community, just

as much as are artistic homes and quaint cottages. In designing the exterior of a small theatre, there are unlimited opportunities for carrying out fantastic ideas and interesting effects. For instance, the suggestion of a picturesque old English Tavern or a refined American Colonial façade with porticoed entrance, white trim, red brick, and old fashioned shop fronts holds alluring possibilities. The motion picture theatre and playhouse may become a potent factor in the architectural development of a community, so that its influence, artistically as well as morally, cannot be over-estimated. The same care and study that have brought about the improvement in the public schools of our villages should be devoted to playhouses with the same good results.

Standardization in motion picture theatre construction should be avoided as far as possible. Considering the problem of theatres nationally, we cannot but be impressed by the possibilities for creating for the motion picture theatre an unique position in its locality that will reflect to the advantage of the industry as a whole.

One of the most striking examples indicative of the possibilities for development of motion picture houses of local interest that has come to the attention of this writer is a 750 seat theatre at Mesa, Arizona. Here, quite appropriately, a simple but emphatic Egyptian treatment has been achieved which places this playhouse apart from theatres of similar size in other parts of the country. The name of the theatre is the "Nile," which is done in characteristic Egyptian inscription over the entrance lobby. The inspiration for the architectural treatment is obvious when it is known that the Salt River Valley of Arizona is considered a rival of the fertile Nile region. The lobby of this small theatre is decorated in Egyptian scarabs and leads into a foyer treated in polychrome tints and embellished with Egyptian heads, cleverly lighted, to enhance the mystic atmosphere. The auditorium is executed in an Egyptian scheme. Along the walls are "sheik" canopy decorations which are done in imitation of rare old tapestry. These canopies are supported by spear points. Encased in the fringes of the canopy are hidden lights which spread a soft glow. The front curtain of the theatre is a reproduction of a scene in ancient Egypt, and the wall decorations are further emphasized with small Cleopatra heads placed between picturesque canopies.

Many other instances might be cited of small theatres which are equally interesting. Every community presents its own problem, however, and in many cities the formal structure is preferable to the more fanciful type of architecture.

In closing, let emphasize this: The motion picture has a firmer hold on rural communities and small towns than it has on the cities. The small town theatre owner as a type is even more progressive than the metropolitan theatre owner. Experience has proved that the smallest community is able and willing to support a modern theatre. Without any organized encouragement, the small town theatre owner has made remarkable advance. With a definite plan of encouragement from those able to provide it, he will give entertainment in modern and comfortable surroundings to every community in the forty-eight states.

INTERNAL DEVELOPMENTS IN THE MOTION PICTURE INDUSTRY

Carl E. Milliken*

THERE IS written somewhere in the Old Testament an injunction which rings with an authority that time cannot destroy. It is: "Set thine house in order." Alexander Pope, whose barbed couplets have certainly never been excelled and probably never equalled, was so struck by the force of the edict that he once exclaimed: "Order is Heaven's FIRST law." Whether we are willing to go so far as to agree with the poet that "Order is Heaven's first law" or not is neither here nor there, but we cannot fail to see that in all nature and in all changes the forces of progress are on the side of order and that eternal battle is waged against rebellious chaos and confusion. Even today we see the fight going on all about us, and there is a continuous clashing of arms as civilization marches on.

In the moving picture industry the fight for order has been an intense one, because the attack has been sudden and concentrated. A period of thirty years encompasses the entire history of the motion picture as a theatre shown form of entertainment, and yet less than ten years were needed for the establishment of harmony and system once the effort was made. Today the moving picture industry is universally accounted a sane business enterprise standing on a good solid bottom with well established principles to guide it and with well defined aims to impel it forward. The development of the industry to its present high degree has not been brought about leisurely nor in the seclusion of quiet study, but out of the heat and turmoil of the fiercest sort of competition, which was not always governed by the most ethical of standards, the rise has been made and the present position attained.

The first few years of the industry's history were chaotic. *Chaos is always the ancestor of order.* The keen men of twenty and twenty-five years ago who first saw the commercial possibilities of the toy plaything set out in feverish haste on the world-old quest for gold just as surely as the forty-niners did when the word came from Sutter's Hill that sent them around Cape Horn or over deserts and through dangers and hardships in search of fortune. Picture

* Motion Picture Producers and Distributors of America, Inc.

pioneers were out to dig gold just as men went to get it in Alaska when the Klondike invitation thrilled the world, and just as Florida's more recent call drew the adventurous blood of our country. The moving picture industry in those first days was groping in the dark, without precedents, without backgrounds, and without experience. But in spite of these defects the moving picture industry went steadily ahead. When dramatic art was a thousand years old, the players were still bedded in barns and said their lines in stable yards. Crudity was still to be found in drawing when it had been known a thousand years. The great newspaper press, to which the moving picture looks as to an elder brother, has had six centuries of development, and from the Gutenberg bible to the newspaper of today is a long and a slow procession of advancement.

The moving picture industry has none of these experiences to draw upon, and it is a fact that those who are in custody of the industry today are to a large extent those who were pioneers in its development. And yet development to a high plane has come, and while the industry makes no claims of perfection, just as no art or medium of transmitting ideas can ever claim perfection, still there is much to be proud of and little to hide as the industry celebrates its thirtieth anniversary and begins to look ahead to another thirty years of growth and prosperity.

Competition we still have, and this is as it should be, but the old helter-skelter days are over. The industry has caught a second breath, and out of the chaotic beginnings when there was time only for commercial considerations and none for moral and educational responsibilities has come a new and happier viewpoint, when the men who control the industry recognize the importance of the instrument which has been placed in their hands and are ready to meet the needs and requirements for its proper use.

From a business standpoint, the industry has settled down and is operating today upon sound, common sense lines which govern other American industries. Reckless extravagance is no more. Neither is there waste of time and effort. No surer indication is possible of what the industry stands for economically in our national life than the attitude of the bankers of the country as expressed in the recent statement of Richard Saunders, former cashier of the National Bank of Commerce in New York, to this effect:

> There is hardly a bank in the country today that does not welcome a motion picture account and that is not willing to extend whatever credit the

statement warrants. The public is supporting its pictures and buying its securities. The quality of the pictures is better than ever before. Elements that make for unsound methods and unsafe investments are gradually being eliminated, and it is not difficult to foretell the day when, with its few remaining problems solved, the Motion Picture Industry will attain even greater heights than it has reached today.

Pictures themselves have advanced along with the development of the business side of the industry, and never have the standards of artistry and wholesomeness been so high as they are right now. Never have there been so many fine pictures which serve in every way their purpose of entertainment as we are privileged to see today. And never has the comment of press and public been so encouraging or the enthusiasm of audiences been so great as at this time. And this I say not by way of boasting but because I wish to give you the facts.

For these changes and improvements to come there had to be reasons, and those reasons are not hard to find. As the moving picture industry settled on a firmer basis and took its second breath, its leaders realized their responsibilities, and they began in systematic manner to fulfill their trust.

Early in 1922, plans were laid for an association of the producing and distributing elements in the industry which would guide and point the way for the completion of certain functions which the industry's leaders recognized as belonging to the pictures, and on March 5, 1922, the Motion Picture Producers and Distributors of America, Inc., came into being with nine of the leading producers and distributors as members. Right here, I might say that that number has now increased to twenty-three members, the twenty-third member having joined the association just two months ago.

Mr. Will H. Hays was called from the cabinet of President Harding, where he was serving as postmaster-general, to become president of the newly formed association. In the articles of incorporation, filed in Albany, New York, the members of the Motion Picture Producers and Distributors of America wrote their code of ethics and laid the fundamental planks upon which the Association has since then operated. They were briefly, to:

> Establish and maintain the highest possible moral and artistic standards of motion picture production; and develop the educational as well as the entertainment value and the general usefulness of the motion picture.

This was not a vague gentleman's agreement but was the legal statement of a legal purpose by a legally organized body and was the definite pledge of the industry to make the moving picture the great factor in the public life that it can be.

Two major matters were presented to the newly formed association in that March four years ago: First, confidence and cooperation within the industry were essential, and second, establishment of the industry on a basis to merit public approval was needed.

At once the machinery was set into operation to bring about simultaneously the two results. Indeed, one was so dependent upon the other that neither could have been accomplished without the achievement of the other.

Extravagance within the industry was checked by direct and forceful methods. Haphazard business manners were succeeded by business methods. No place was left for those who were slipshod in their commercial transactions. Truth became paramount in advertising. The industry began to be a business and not a game. A leavening was at work within the industry, and the problems were being met and solved.

Film Boards of Trade were made national in character and in thirty-three key cities today these boards made up of representatives of producing and distributing companies and exhibitors, conduct the field business of the industry in their respective territories. General headquarters for the Film Boards of Trade are in the offices of the Motion Picture Producers and Distributors of America, and through the machinery thus afforded the business of buying and selling is carried on with the greatest ease and facility.

The industry was the first large industry to adopt country-wide commercial arbitration in the settling of its trade disputes. Arbitration boards were established in the thirty-three key cities, each board being composed of three exhibitors and three distributors, a seventh member being elected by the board in the event of a tie vote. So successful has the industry been in its arbitration that the recent report of the Arbitration Society in America proves it to be, for the second year, the outstanding example of use of the system in America. No other industry has even approached it in successfully settling trade controversies. For instance, last year, 11,887 disputes, involving $2,542,544.40, were disposed of by the boards of arbitration. Of these, 4,269 disputes were settled before submission to the boards, while 5,450 awards were made. Only 22 disputes required a seventh arbitrator, and of the thousands heard, only 17 were litigated after arbitration. Only one was litigated before submission to arbitration.

Further, the Industry, through the Motion Picture Producers and Distributors, has adopted a uniform contract for the rental of films, has brought about closer co-operation between the exhibitor and the distributor, and has harnessed the forces within the industry into a working unit for the good of the industry. Working closely with the Association of the Motion Picture Producers of California and the Association of Motion Picture Distributors and Exhibitors of Canada, it has widened its scope.

Fraudulent motion picture enterprises have been relentlessly fought and have decreased enormously. Support of better business bureaus has been enlisted for countrywide betterment in the business aspects of the industry, and advertising clubs have been brought into a working relationship for the improvement of advertising methods as well as the improvement of advertising honesty.

I might mention in addition any number of definite examples to show how the motion picture industry under the new impetus given it four years ago has gone about its plan of stabilization. For instance, several months ago, the Association of Motion Picture Producers of California in conjunction with the Motion Picture Producers and Distributors of America, Inc., established in Hollywood what is known as a free centralized casting bureau for extras. Prior to that time, extras employed in motion pictures—and the industry uses more casual labor than any other industry—were paying ten per cent and upward of their wages to employment agencies. They were being charged for not only the first placement but for all subsequent placements. To relieve this situation, the producers agreed to establish a centralized casting bureau through which all placements of extras would be made without cost to the man or woman employed. The bureau opened in January of this year, and already more than 60,000 placements have been made—not of sixty thousand extras, of course, but that many placements.

The influence of such a casting bureau is more far-reaching than a cursory view indicates. For instance, you can see how a bureau like this will eventually wipe out of existence questionable schools for acting, scenario writing, and the like which have preyed on a gullible public. Since these schools will have no power to get positions for their students except through the casting bureau which operates without cost to the employee, there will be no excuse for their continuation. Thus, not only will thousands of dollars be saved for the extras, but they will be protected in other and just as substantial ways.

Another indication is that the industry has placed itself on record for the protection and care of animals used in the films and has so carefully followed the laws it has laid out for itself in this regard that the American Humane Society and other groups have strongly commended the producers for their enlightened stand and called on other industries and groups using animals to emulate the motion picture industry.

Likewise, schools have been established in the California studios for children employed in pictures, the teachers being paid by the producers but selected by the Los Angeles Board of Education, The children are under supervision for eight hours a day and have regular school hours, recreation periods, and only short working hours—usually about ten minutes a day although some are used as much as an hour upon occasions.

In such manners as these I have mentioned the motion picture industry has regulated itself and acquired the stability and solidarity it may well boast of. It remains now to be seen what has come of the program to promote the public's good and win the public's good will and respect.

Right here I want to dispel a suggestion or, indeed, a belief that the moving picture industry is owned by a very limited group of individuals. Looking over the financial statements of less than half a dozen of the larger producing and distributing companies, I found that they have outstanding 3,554,115 shares of stock in the hands of no less than 11,516 shareholders resident in forty-five of our states and no less than twelve foreign countries. Motion picture stocks are traded in daily on the exchanges, and it is perhaps worthy of note that during the recent flurries when the stocks of other industries, older and formerly deemed perhaps more substantial skidded downward in value, some to remain at lower figures, the motion picture stocks were affected little if any by most speculative trading, and if they did lose a few points, they quickly regained their former ratings. The industry is not therefore owned by a small group. More and more, it is becoming the property of the public.

Patrons of the industry now average 100,000,000 persons a week in this country. Three hundred thousand men and women are employed in its various branches, and there are 20,233 theatres throughout this country showing pictures. Six hundred and nine-six feature pictures were produced last year and more than twice as many short subjects, and for the coming year 811 are promised. A billion and a half dollars are invested in the industry, which is now ranked according to government figures as the fourth largest in point of capital invested in the United States. These figures indicate the happy results of business-like methods.

One of the first steps taken by Mr. Hays after entering upon his duties as president of the Motion Picture Producers and Distributors of America was to call a conference of the representatives of national, social, religious, welfare, and educational bodies to secure their advice and co-operation in achieving the purposes for which the association was formed. Out of this conference, the Committee on Public Relations was formed representing through their member organizations many millions of men and women interested in public welfare. The committee proceeded to act as an advisory body to interpret the desires of the public in relation to the moving picture entertainment and to develop pictures to a higher plane through a systematic plan of supporting the best productions. It was evident that if the commendable pictures were successful from a business point of view more of the same quality would be produced.

At the end of three years the committee found that its work had increased to such an extent and grown to such proportions that expansion on a broader scale was essential. The committee itself, therefore, in March 1925, asked that a full department be created within the Motion Picture Producers and Distributors of America with power and personnel to carry on the increasing work. This proposal was made to Mr. Hays and his associates who acquiesced, and the Department of Public Relations accordingly was established as the industry's official means of continuing and further developing public co-operation as initiated by the Committee on Public Relations. The committee then disbanded, each organization, however, continuing its contact through the so-called "open door" policy which was established.

The latter policy, perhaps, needs a word of explanation. It is the industry's invitation to the public generally to come to it with helpful suggestions and constructive criticism which may be used for the further advancement of the screen as an entertainment, moral, and educational force, and it is a policy as broad and as expansive as the public wishes to make it. Through the "open door," the thoughts of the public can flow into the industry to the very source of production, and again through the open door the industry can acquaint interested groups and individuals with its processes of development.

After bringing the public into closer co-operation and affiliation, the industry began in very definite ways to prove its good faith and to fulfill its obligations to the public. Briefly I shall outline a few.

We have witnessed in our age the development of a strange psychology which sets at defiance certain rules and conventions under which the world has operated for years. The printed page and the spoken drama have been extremely free in discussions of topics which previous to this era were discussed in whispers if at all. As a result, a certain type of book and play has become rather prevalent and widespread. To transfer these ideas to the screen, which reaches millions whereas a novel is read by a few thousands at most, did not conform with the ideas and ideals of the members of the Motion Picture Producers and Distributors of America, and so accordingly the men who make motion pictures decided more than two years ago that more or less prevalent type of book and play should not become the prevalent type of motion picture. A system was set up to that end and here is how the system operates:

When any member company is offered the screen rights to a book or play of a probably questionable nature, representatives immediately inform the offices of the Association. If the judgment of the member company is confirmed that picturization of the subject matter is inadvisable a notice is sent to all the other member companies giving them the name of the objectionable book or play. During the past year, more than 100 such books and plays have been kept from the screen despite the fact that several were best sellers. The method is thoroughly legal and has proved efficient. At the same time, this is not censorship in any sense of the word. No censorship could have brought about the results this formula has attained, nor does the plan by any possible interpretation limit the production of vital or artistic pictures. The whole attitude of the industry and of the Motion Picture Producers and Distributors of America, Inc., toward censorship, it might be stated right here, is summed up by Mr. Hays in the following words:

Political censorship of motion pictures is a mere incident in our whole situation. It is as un-American in conception as it is ineffective in execution. The American people are fundamentally against political censorship of any method of expression. They are properly against censorship of press, of pulpit, and of pictures. Our concern is to make better pictures all the time. The people will take care of the whole matter of censorship.

In further serving the public, the Association has collected 52 programs of pictures especially suitable for children which are offered to any community desiring them for showing in the theatres on Saturday mornings. The Saturday Morning Movies, as they are called, are now being used in several communities with success directly proportional to the amount of interest exhibited by the parents and guardians and teachers who control the attendance of the boys girls. These are the best sort of entertainment pictures and are offered for ten cents admission for children wherever shown.

Last fall a Religious Motion Picture Foundation was established by the Harmon Foundation with the co-operation of the Federal Council of Churches of Christ in America and the Motion Picture Producers and Distributors of America. Pictures will be produced by this foundation for use in the churches in conjunction with the sermons. The groundwork was laid by Mr. Hays. He had a series of experiments conducted to show that pictures helped church attendance and added much to the sermons.

A few months ago, the Eastman Kodak Company, a member company of the Motion Picture Producers and Distributors of America, announced that it would proceed at once with the development of teaching films for use in classrooms. These will be correlated with selected courses of study and in accordance with a definite educational plan and will be used exclusively in the schoolhouses.

Interested groups have been brought into closer co-operation with the industry by means of consultations held before the actual production of pictures. For instance,"America" was made at the suggestion of the President General of The Daughters of the American Revolution. "Thank You" was made with the help of a group of ministers who went over the scenario. "The Scarlet Letters'" scenario was read and discussed with ministers, leading laymen, and others interested in this classic's picturization before work began.

Furthermore, the screen has been liberal in using its facilities for worthy causes. This spring the General Federation of Women's Clubs is conducting a music memory contest in the motion picture theatres of this country because they realize how great is the contribution of the theatre to musical appreciation.

The National Child Health Week campaign found the motion picture industry ready with its aid in spreading the doctrine of child health through special slides prepared by the Motion Picture Producers and Distributors of America and used in the theatres. Be-Kind-to-Animals-Week found the motion picture its friend, and the news reels broadcasted its plea of humane treatment, and so on in countless ways.

One of the biggest things done is the wide distribution of moving pictures to the institutions for the helpless. Prisons, hospitals, orphanages, homes for the aged, and the like—more than three thousand in all—are using motion picture service regularly. Of these more than five hundred received free service. And the pictures are the same as those shown in the regular theatres.

Of course, the biggest thing the industry has done for the public is the improvement in pictures themselves, and I have saved that for last. Let me call your attention to a few of the current pictures that are being shown to the hundred and odd million patrons now. There is "Ben-Hur," with its thrilling chariot race and its inspiring story of the Nazarene; there is "The Big Parade" with its fine conception of the World War and the part the youth of this country played in it. "Mare Nostrum" is another war picture, revealing the spy system. "The Sea Beast" is a tale of the whaling industry and the courageous followers of the sea. "Stella Dallas" is the story of a mother's love. "The Black Pirate" is a fantastic and thrilling pictureplay in color. "For Heaven's Sake" is Harold Lloyd at his funniest. "The Iron Horse," "The Pony Express," "The Vanishing American," "Thank You," "Lightnin'," "The Ten Commandments," "The White Sister," "Romola," "La Boheme," "The Fool," "Nell Gwyn" are but a few of the other outstanding pictures, and there are literally hundreds of pictures that are fine and wholesome and splendidly entertaining in every sense of the word.

The industry has best served its public by bringing such pictures to the public, and it has brought them by obtaining the best actors and the best writers and the best directors and photographers available. Its development in these fields has been perhaps the outstanding feature of the past year, but you are as familiar with these improvements as I am.

I have not meant to imply that the moving picture and the moving picture industry are perfect. There is still much to do, and we will go on doing bigger things as time advances. But I am sure that you, as careful observers, will agree with me that something fundamental has controlled the popularity of American pictures and made them not only the entertainment of the masses in this country but the entertainment of the masses throughout the world. The American film industry today supplies nearly ninety per cent of all the pictures produced in the world. This could not be true unless American pictures were good pictures. Merit and merit only could have survived the competition and adverse legislation which other countries have leveled at the American pictures. As one man has said: "Our pictures travel on the passports of interest and merit." The truth of this is admitted by the Manchester Guardian, which says: "There is no doubt that the general public would rather see any average American picture than the most vaunted British 'super' film ever made. American films, with all their faults, are swift and neat and workmanlike; they are expertly photographed, made by men who know every inch of their job, and, above all, they bring the public the stars they have come to love."

Our pictures abroad are doing two tremendous things. First, they are taking the world our ideals and our standards of living and are breaking down age old prejudices which will enable man and man and nation and nation to live together on terms of peace based on real understanding and mutual regard; and, second, they are advertising American goods to the world. As one editor recently said, our films are doing more to sell American goods than 100,000 traveling salesmen could do.

One thing occurs to me in which you can have a real part. Before long the motion picture industry will need a bureau of research, and the relationship between your organization and our organization offers a good basis for the study of the problem. It is something that you can think about and plan for with us.

If the accomplishments of the motion picture industry have been great, and they have, then the future is infinitely greater in prospect. While today there is little to apologize for and very much to be proud of, there is yet much to be done. The time has come for us to begin to think constructively of what that future work will consist of. And we can begin thinking constructively in no better way than by acquainting ourselves with the thought: What is Right With the Movies?

Everything will be entirely right if we all, industry and public alike, give our understanding and appreciation and broadminded interest and co-operation to the task that lies ahead.

DISCUSSION

PRESIDENT COOK: This meeting in Washington, gentlemen, is going to be an outstanding and long-remembered one from the rather unusual contact with the administration of our government. Yesterday, we were the guests of the President, and to-day we have as our guest an ex-governor of the State of Maine.

For years we have been extremely anxious to establish as close an affiliation as we could with that large body called the producers of motion pictures. Our membership is made up largely from the manufacturing and commercial end. With the producers we have had less intimate connection, although some of our members do belong to the producers' section. During the last six months we have made tentative plans with the producers; namely, the Motion Picture Producers and Distributors of America. We have been happily encouraged by the members with whom we have come in contact and particularly by Governor Milliken, who was secretary of the organization, Mr. Hickman Price, assistant to the president, and Mr. Hays himself, who is interested in the Society. We think this speaks extremely well for the future of both organizations, may I say without undue egotism. The Society has information of value to the producers, and the producers in turn have real means of assistance to us. We need the technical advice of their section, and it looks as if we were going to have it.

The Society has had a very great privilege and treat in listening to this history of the development of the industry from Governor Milliken. The outstanding thought we gather all the way through this paper is the serious sense of obligation to the public realized, felt, and practiced by the Producers' and Distributors' organization. This is one of the elements of the success of all modern big business—public interest—and that is shown through every line that Governor Milliken read to us. We are particularly gratified by his closing line about the co-operation between the two organizations. We hope this meeting will mark a closer and mutually beneficial relation between our society and the distributors of pictures.

MR. PALMER: Yesterday, in talking with one of the members, he said one of the things he thought the industry needed more than anything else on the technical side was a research department where new devices could be tried out and proved good or bad. My job is such that whenever any new device comes up for approval they give it to me to pass on, and I am so busy with production work that I don't have an opportunity to really try out these things. I was pleased to have Governor Milliken add his remarks about the matter at the end of his talk and emphasize again the necessity for a research bureau where new devices could be tried out. I think that we are missing a lot of things we should be using because we do not have such a department. For instance, a lot of things are being used abroad in the motion picture studios which may be better than what we have.

President Cook: That is a very constructive suggestion, and I think it may be possible for the Society in some way to function as an investigating bureau of this sort provided the expense of such investigation by its members can be shared by the associates which would benefit therefrom. I think a working arrangement of that sort would be more efficient than an independent organization of a few individuals and would cover a wider range of art and science and be more comprehensive in our organization. I think we are converging toward a working arrangement whereby our society and the producers may bring to their work business efficiency and administration economy. Any suggestions to the Board of Governors along that line will be given earnest consideration.

Mr. Hill: I want to add to what Mr. Palmer has said that the necessity for a clearing house in the theatre field is as pressing as it is in the studio. Many devices are offered to the theatre, and it is impossible for any one man to weed out the good and bad. Much of it is worthless and much must be gone through to find out where real progress has been made. Research on this would mean a great deal; in fact, as much as research in production would mean to the studio.

Governor Milliken: The suggestion lies in our minds, but it means first a clearing house on what has been done to pass upon it and makes it at once available; secondly, independent, forward-looking research always financed by the industry as a whole. We should first have to find out what is being done and put it to the service of everybody; then, develop the new things.

NOTE ON THE STRENGTH OF SPLICES*

S. E. Sheppard and S. S. Sweet

A NUMBER of contributions to the question of splicing have already been presented to the Society.[1] In particular, at the last convention, Mr. E. J. Denison presented a very valuable paper on "The Importance of Proper Splicing" which has been published in the Transactions of the Society, No. 24. While Mr. Denison's paper covers very fully the ill effects of improper splicing and gives a very good résumé of the conditions which should be fulfilled in making a good splice, it appeared worth while to us in view of the importance of the matter to make a little more intensified study of what might be termed the mechanics of splicing.

Operations in Making the Splice

The actual operations have frequently been discussed; they are essentially:—

(A) Scraping
(B) Application of cement
(C) Alignment or placing
(D) Drying

Experimental Work

The tests applied and discussed in this note were, first, direct tensile strength tests on the dynamometer previously described,* secondly, actual wear and tear tests on projection machines. The tensile strength tests measure only the goodness of the splice considered simply as a joint or weld but give no information as to its registration and fitness. These factors as well as the strength are tested in projection trials. Fig. 1 shows the proposed S. M. P. E. dimensions for film splices.

In the following, except where otherwise stated, the splice was a full hole splice as shown above. In the first tests, seasoned film and fresh Eastman Universal Cement were used.

* Communication No. 276 from the Research Laboratory of the Eastman Kodak Company

[1] M. Briefer, *Trans.* S. M. P. E., 1922, No. *15*, p. 63
H. H. McNabb, *ibid*, 1922, No. *14*, p. 40
E. J. Denison, *ibid*, 1923, No. *17*, p. 179, and *ibid*, 1925, No. *24*, p. 131
S. E. Sheppard and S. S. Sweet, *Trans.*, S. M. P. E., 1925, No. *24*, p. 122

Scraping Variations

A proper scraper with a square edge is superior to either a razor or knife, as has been noted before, mainly because of the greater danger of slicing and gouging with a razor. The splices we prepared were in general not beveled. As will be noted later, there are advantages in a properly made bevelled splice, but since quite satisfactory splices can be made without beveling, the extra trouble can well be avoided. The importance of proper scraping was shown by comparison of knife scraped splices (imperfect removal of gelatin)

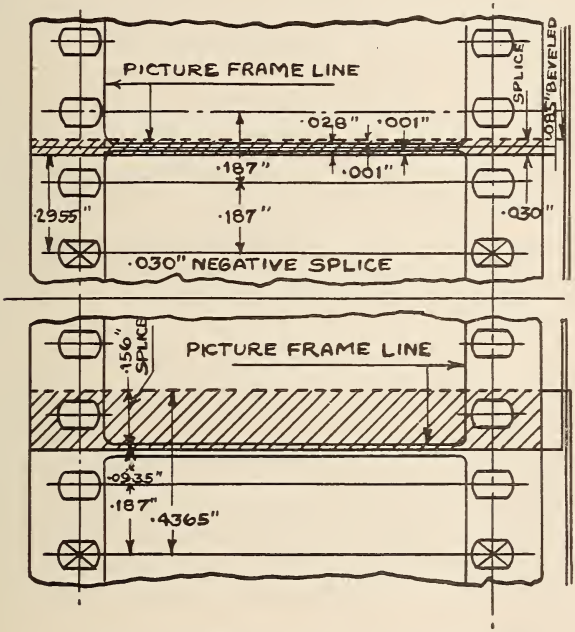

Fig. 1. Proposed dimensions for film species.

average tensile strength 2.6 kilograms—with razor scraped splices—average tensile strength 5.2 kilograms. Values ranging from 3 to 9 kilograms were easily obtained by slight variation of the scraping. The data bear out fully the point made by Mr. Denison and others on the importance of this step.

Application of Cement

The necessity of using a uniform cement not allowed to change by evaporation may again be emphasized. The cement may be applied first to either the under film, which is scraped, or to the upper side of unscraped base. It should be applied with the tip of the brush and uniformly spread, so that it will be free from air bells. The former procedure is the more usual. Provided the *amount* of cement applied is correct, there does not appear to be any real difference, although some results have suggested a slight inferiority in spreading on the upper unscraped film. Much more important is the adjustment of the *amount* of cement, whereby the chief point is avoidance of excess. Under the conditions used, excess of cement produced an average drop in tensile strength of the splice from about 10 kilograms to 7 kilograms. Various effects resulting from excess of cement will be noted later.

Pressure and Drying

Sufficient pressure is essential if a true weld is to be made. The effect of *time*, principally allowing diffusion and drying, was shown by keeping splices and testing after 16 hours. The tensile strength increased from about 9 kilograms (fresh splice) to 12 kilograms. This effect of time may be replaced largely by heat, as provided in certain automatic splicing machines.

Alignment and Registration

While these factors do not, for small variations, notably affect the straight tensile strength of a splice, they are vitally important for actual life. They have been very fully discussed in previous papers and amply illustrated in Mr. Denison's paper. Perfect registration of the perforations is not uniformly accomplished by hand splicing, and our tests fully bear out Mr. Dension's conclusion "to splice film properly splicing must be done automatically."

Width of Splice

The width of splice is determined as a compromise between certain advantages and disadvantages. It is certain that a splice wider than the full hole splice of 0.156 inch accentuates one set of evils of bad splicing and in particular means increased bending radius and lower flexibility.. Arguments for splices narrower than the half width of this, 0.078 inch, have been presented, and undoubtedly when beveling is resorted to, such narrow width splices can be successfully made. But under practical conditions making this type of splice demanded more care than is available. The width question apparently narrows down to a comparison of the full hole 0.156 inch splice and the half width 0.078 inch, (cf. Fig. 1).

Splices of these two widths were made under exactly comparable conditions with three different types of automatic splicing machines. Tensile strength tests were made of the splices and also of the unspliced films. Practically identical results were obtained for a large number of tests:

Unspliced film	14.2 kilograms
0.078 inch splice	10.5 "
0.156 inch splice	10.4 "

with a loss of strength of about 25 per cent. Wear and tear tests were then made with both types of splices on two different types of projection machines. We were again unable to establish any conclusive superiority of one over the other. On one projector, the 0.078 spliced film ran 540 for an average of 3 runs, the 0.156 inch spliced film, 520; and the unspliced film, 600. On the other type of

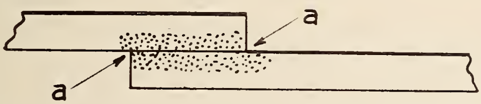

FIG. 2. Cross Section of splice, showing diffusion of solvent into film. "a" "a" indicate points of weakening.

projector, the 0.078 inch splice made from 1400 to 3500 runs; the 0.156 inch splice from 1420 to 3550. Unspliced film on this projector would run from 1500 to 3500 times. Consequently, for good splices made automatically, the 0.156 inch and the 0.078 inch appeared equally satisfactory.

On Some Conditions Determining the Strength of Film Splices

We have included some considerations which seem generally valid for a splice between two films;

I. *Geometrical Factors*

A. Sharp corners introduce a source of weakness, (Fig. 2). Other things equal, a beveled splice is ideally superior.

B. Localized strains induce weakness. A bolt cut with a thread as shown at *A* in Fig. 3 resists shock better than the one shown in *B*, although diameter at the threads is the same.

II. *Cement Factors*

A. Obviously the tensile strength of the binder which is left behind by drying the cement should be of the same order as that of the film support. The necessity for keeping the cement from evaporating has been noted.

B. The softening action of the cement solvent on the film base does not necessarily pass away on drying. There is some permanent effect due possibly to re-aggregation and unequal straining of the support. Irregular diffusion due to excessive scraping or to leaving the cement on the film too long before joining will increase this, (cf. Fig. 4). This softening action may accentuate local weaknesses at the sharp corner of junction of the two pieces of film.

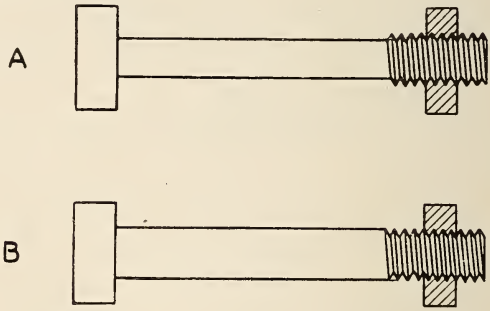

FIG. 3.
The diameter of the threaded part of bolts is the same in each case, but by decreasing the diameter of the shaft as in "A" the resistance to shock is increased.

C. The penetration of the solvent together with associated swelling and shrinkage may lead to warping or buckling at the joint, (Fig. 5). If *excess* of cement is applied, it oozes out and being held by one surface of the film intensifies the corner weakness already referred to, (cf. Fig. 6). Again, the cement may be left in contact with one piece of the film longer than with the other, resulting in unsymmetrical diffusion and swelling and a tendency to warp the joint. Changes in the distance between perforations due to swelling and shrinkage from solvent penetration will increase warping.

A good splice will be a true *weld*, the interface of separation vanishing. In Fig. 7 are shown enlarged photomicrographs of cross-section of three splices. A shows a good splice, the division having vanished; B shows imperfections at the edges; while C is a poor

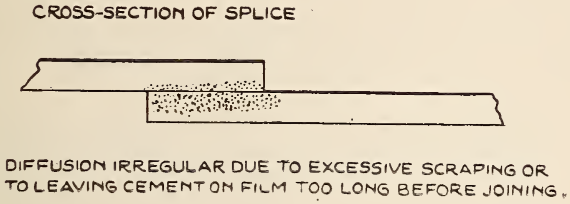

FIG. 4.

FIG. 5. Buckled Splices.

splice with imperfect adhesion. In Fig. 8 the ends of the cross-sections are shown enlarged further.

The authors desire to acknowledge some valuable suggestions by Dr. E. K. Carver in the course of the work.

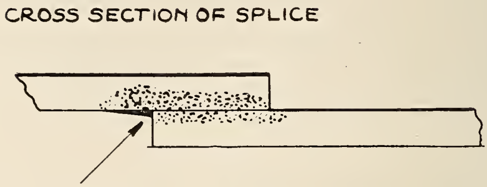

FIG 6. The shrinkage of cement oozing out at the point indicated causes the film to buckle.

FIG. 7. Cross-sections of splices.

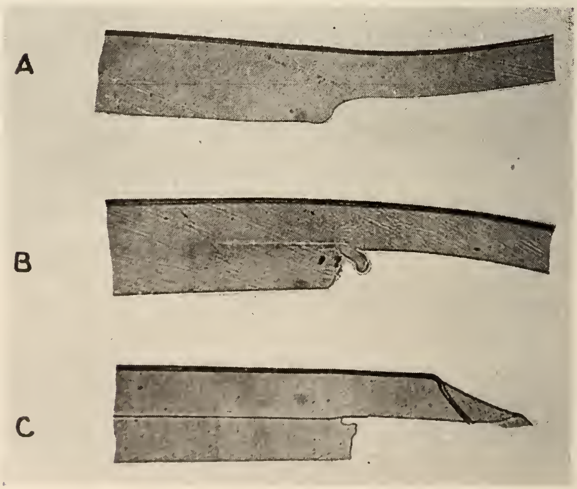

FIG. 8. Cross section of splice ends.

DISCUSSION

Mr. Richardson: In making these splices, what procedure was used; that is, what did you use for pressure?

Dr. Sheppard: In the case of the first series, the splices were made by hand and in the second case with a Bell & Howell splicer.

Mr. Richardson: The real question is this: You have shown a full hole splice having 10 or 14 kilos strength and also a half width splice having essentially the same strength. Such accurate procedure is seldom used in the theatre projection room. Which, in your opinion, would be the stronger splice when not made with the utmost care?

Dr. Sheppard: I think the full hole splice would be preferred.

Mr. Denison: I think Dr. Sheppard's paper is very comprehensive. With regard to the width of the splice, we use the full hole splice (0.156") only because the operator demands that type; the narrow splice is just as strong. We equalize the margin on both sides of the perforation in order to eliminate the possibility of fractured perforations breaking through to the edge of the film. It is absolutely necessary in our exchanges to handle a certain number of films that have corner fractures. After the film is from thirty to sixty days old, it generally develops slight corner fractures. One of the most important steps in making good splices is the proper application of cement. We have, as I stated before in a paper before the Society, two distinct operations in making a splice. Cutting and scraping the film is only preparing it for the cement, and since the cement attacks and softens the celluloid base, in the finished splice you have an amalgamation of two pieces of celluloid. We have had some trouble with splices splitting at the edges for the reasons Dr. Sheppard pointed out. It has given me a great deal of pleasure to listen to Dr. Sheppard's paper because he has verified what I have said before regarding splices.

Dr. Gage: It is obvious that splices made on the machines at the factory or in exchanges do not cause trouble, but many splices are made by projectionists who have to make them in a hurry, and it seems to me that the next step would be to take up the matter of supplying the projectionist with a device—simple or complicated—which would make a really reliable splice. I think this is important for the industry.

Mr. John G. Jones: There is a splicing machine on the market that answers all requirements for making good splices. It is very difficult for the projectionist to make satisfactory splices with improvised splicing blocks.

President Cook: I want to make one comment on this. Everything seems to depend on the way in which a splice is made. In our libraries we have hundreds of thousands of splices, and everything depends on the technique.

Mr. R. Hubbard: The doctor spoke several times in his paper of the proper heat being applied to the splice. As I understand it, he did not say what the proper heat was. Were any experiments made on this?

Dr. Sheppard: I think it might be desirable to define matters more closely by determining the best temperature. The splicing machine used had a heating device which gave a splice as strong as produced by drying 16 hours under pressure, but the temperature was not measured.

Mr. Richardson: To bring out my point: we are dealing with practical conditions. Is it not a fact, Mr. Dension, that under ordinary conditions greater width adds strength to the splice, even though that might not be true under ideal conditions described by Dr. Sheppard?

Mr. Denison: I don't think so. If a splice is properly made the narrow splice is just as strong as the wider one but as I have stated before, the projectionists demand a wider splice. They generally cut out the narrow ones. We have tested splices of various widths, sufficiently to determine that while a narrow splice has sufficient strength, the wider one (0.156") is better for practical purposes because the projectionists do not remove them from our prints.

The average projectionist is not properly equipped to make good splices. I daresay that not one in a hundred has the proper splicing equipment in the projection room. Most splices made in the projection room are made entirely by hand. They are registered and dried with the hands with the result that the splice either cups or buckles and unless removed from the film, will eventually cause damage. The splice must be uniformly scraped, cement must be uniformly applied and the cement must be in good condition. The cement must be applied quickly, and a uniform pressure with heat must be given to eliminate the possibility of cupping or buckling.

Mr. John G. Jones: If a poorly made wide splice has 75% of the strength of the area cemented, it would, of course, be stronger than a poorly made narrow splice with 75% of the area cemented, so that the wider splice would tend to give less trouble, the wide splice being 0.156" wide.

President Cook: If I have understood Mr. Denison correctly, the evidence of his experience has been that there is no advantage in the wide splice. Am I correct, Mr. Denison?

Mr. Denison: Yes, sir, from a mechanical and physical standpoint.

Mr. Richardson: My question has apparently not been understood. I grant you that if the narrow splice is properly made, it is just as strong and better than the wide one. I believe, however, that the splice is not properly made in ninety-nine out of a hundred cases, and in this case the wide one is stronger than the other.

Dr. Sheppard: I think you cannot make a real comparison between a bad narrow splice and a bad broad one. The true test is when both are made as properly as possible. I don't think you can really compare the two when badly made. As I stated in my introductory remarks, one object in doing this work was to supplement the excellent surveys by Mr. Denison and others on splicing under field conditions by laboratory tests. I think we are in agreement on the fundamentals of this matter. The only question remaining is whether if a splice is poorly made it should be broad or narrow. I don't think it matters. The essential thing is that a splice be rightly or properly made, and if it is bad, the narrow and broad can not be compared. There are probably ten different elements involved in an analysis of the technique. It is very difficult to reproduce a bad splice. I think that sums up the thing. The most essential thing is to get the projectionist a good splicer.

Mr. Townsend: That last statement is just *it*. Get him something to make a splice with. As Mr. Jones said, there are machines on the market to make a good splice, but get the theatre manager to buy one! If the projectionist asks his manager for a splicing machine costing $20 or $25, he is likely to be fired.

Dr. Sheppard: Then we must get sense into the managers

Mr. Townsend: I think a hand splice in any case is a makeshift. Splices are not necessarily made in a hurry in the projection room. They are not made at the time they break in projection. A good splicing machine is to my mind a necessity in any theatre. The difficulty is to get the managers to realize this. In our theatre I use a splicer which I think is good, but I have not made experiments to get conclusive data on it. I was in a position to sell splicers to theatres on a commission. I offered to sell them less the commission for the benefit of the projectionist, but the theatres wouldn't buy them, and only our three theatres out of about fifty in the city of Rochester have one. Not a single manager would buy one at $22.50 less 33⅓% discount.

PRESIDENT COOK: The Chair is glad to find such accord in a discussion.

MR. EDWARDS: I might say, that in actual projection practice, the narrow patch which is advocated by the laboratories, is not found satisfactory. We find them opening up every day and have to temove them if the continuity of the show is to be preserved.

THE EFFECT OF PROJECTION LENS FLARE UPON THE CONTRAST OF A MOTION PICTURE IMAGE*

Loyd A. Jones and Clifton Tuttle

Of THE numerous factors which influence the motion picture screen reproduction of object tone values, the effect produced upon contrast by projection lens flare has received relatively little attention. Although this defect of image forming systems has been treated in texts on geometrical optics, the material is not in a form from which conclusions can readily be drawn regarding its practical effect upon image contrast. E. Goldberg[1] has very carefully considered the subject of flare in photographic objectives, but since the conditions of projection are essentially different from those existing in the camera, his results are not directly applicable without modification. It is the purpose of this work to examine the relative characteristics of the motion picture positive and its projected image and to attempt a quantitative explanation of the reduction in contrast which takes place upon projection.

In the pursuit of this problem, it is desirable to make all necessary measurements under conditions which approximate closely those of actual motion picture projection, and with this end in view the motion picture densitometer illustrated in Fig. 1 was designed. An aspherical Bausch & Lomb condenser (B) of the type recommended for tungsten projection condenses a cone of light from the monoplane filament 900 watt Mazda lamp (A) onto the film at X. A water cell (C) containing a copper sulfate solution prevents excessive heating of the film which must remain stationary in the beam while measurements are being made. The condenser is placed so as to form a filament image within the projection lens D. The projection lens forms an image of the film on an opal glass screen at E. Light from a small area of this image passes through a hole in the glass screen (F) and is directed by two prisms shown in the figure into one field of a Martens polarization photometer (M). The second field of the photometer is illuminated by a beam of light KK from the same source as is used for projection. The use of the same source

* Communication No. 277 from the Research Laboratory of the Eastman Kodak Company.

[1] E. Goldberg, "Der Aufbau des Photograpischen Bildes," Enzyklopädie der Photographie, Heft 99.

for both fields eliminates the error which arise from a fluctuation of line voltage if a secondary lamp were used as a comparison source. The necessity of constant voltage control while reading the instrument is thus obviated. The Martens polarization photometer[2] is one of the most satisfactory instruments for the comparison of light intensities. The field is made up of two semicircles separated by a sharp dividing line. When a balance is obtained, the dividing line completely disappears, which makes it a very simple and accurate instrument to read.

The aperture plate which holds a single frame of the film is movable in two directions and is actuated by rack and pinion adjustments from the screen end of the instrument. Thus, any desired area of the picture may be projected through the hole in the screen

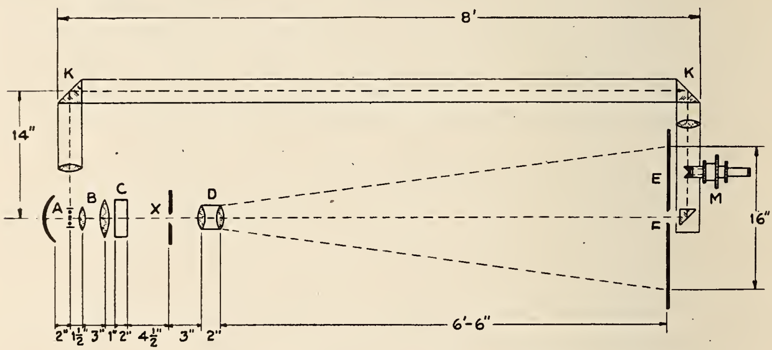

Fig. 1. Motion picture densitometer.

onto the field of the photometer. A picture 16″×12″ is projected onto the screen, and a circular area about ¼″ in diameter is received in the field of the photometer.

The projection lens is carried in a revolving turret provided with mountings for various lenses. However, for the data reported here, only one lens was used—a two-component doublet, 4 inch focal length projection lens of F/2.1 aperture. The first component was cemented and the rear uncemented.

Definition of Terms

The relative brightness of various areas of a projected picture depends chiefly upon the transmission (*T*) of the corresponding

[2] Physik, Zeit. (Leipzig) 1 p. 299, 1900.

areas on the positive film. Transmission is defined as the ratio of transmitted to incident light. If perfect projection were possible, if there were no scattering of light from its correct path, the screen brightness of any portion of image area would be directly proportional to the transmission of the corresponding area of the positive film. This *ideal* value of screen brightness we shall refer to as B_i. For practical projection conditions, where scattering of light takes place at the film and within the projection lens, the value of screen brightness will in general be higher than the ideal. This *effective* value of screen brightness we shall call B_e, and it will be defined as the ratio of brightness with and without the positive film in place.

Of the light which enters the projection lens after passing through the film, the major portion falls on the screen to form an image of the film. A smaller portion of this light is reflected at the glass-air surfaces of the lens components and does not reach the screen at all. A third portion after two or more reflections within the lens passes on toward the screen with its direction altered from its correct path. This light produces a more or less uniform brightness upon the screen which we shall call *flare brightness*, B_f. The value B_f is equal to the difference between the values B_e and B_i.

The total amount of light which enters the lens is dependent upon the average transmission of the whole frame. This value, which we shall call *average ideal transmission* (avT_i), was computed for all cases cited in the data from measurements of the ideal transmission values of the different areas making up the picture. Since all of the areas used are of some regular geometrical shape, the computation of (avT_i) can readily be accomplished.

The data given in this paper were taken to ascertain the amount of flare brightness and its approximate distribution over the screen. The effective brightness is readily measurable by means of the motion picture densitometer already described. Two possibilities are open in the measurement of ideal brightness; the transmission can be measured upon a densitometer which is not subject to flare (one containing no lens), in which case the value must be converted to actual projection transmission. The value of transmission as it is usually measured in contact with opal glass will be higher than the value of specular or projection transmission. The relation between these two distinct values has been shown by one of the authors[3] to be a rather complicated function involving constants which are dependent upon the photographic material used.

A close approximation to B_i can be obtained by using the motion picture densitometer with all light excluded from the lens except that passing through the area being measured. This latter course was adopted in the present work. A pinhole mask over the film admitted light only from a small area. It was assumed that the light from the out-of-focus images of this small area [one thirty-second inch (.031″) in diameter, approximately 0.1 per cent of the total frame area] was negligible in comparison with the effect being measured which is the light from the out-of-focus images of the whole frame.

Flare Brightness with Spot of Various Contrast Values on Uniform Background

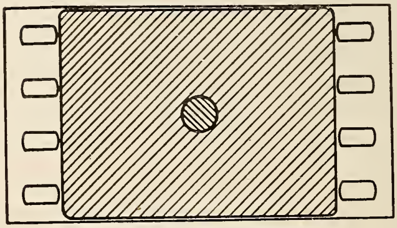

Fig. 2. Arrangement of areas in test frame.

Flare Brightness with Uniform Density

The simplest type of subject to consider is that in which a film of uniform density covers the field. Results from measurements of a number of uniform films of various transmission values are summarized in Table 1.

Table 1

B_e	B_i	$B_f = (B_e - B_i)$
67.95	64.19	3.76
45.84	43.24	2.60
18.72	17.67	1.05
6.69	6.31	0.38
3.49	3.29	0.20

The value given in the third column is the screen brightness due to non-image forming light.

[3] "The Relation of Diffuse to Specular Density," by Clifton Tuttle, J. Optical Society of America, June 1926.

As a next step in the problem, a series of specimens such as shown in Fig. 2 were measured. A small spot one-eighth inch in diameter occupies about one fifty-fourth (0.019) of the total area measured. For images of different members of this series, the brightness of the spot varied from less than 1 per cent to 60 per cent of the unobstructed screen brightness, while the background brightness varied over the same range but in the opposite direction. There results a series of different contrast values varying from a dark spot on a light background to a light spot on a dark background. Readings summarized in Table 2 are averages of eight values for spot brightness and eighteen values for background brightness.

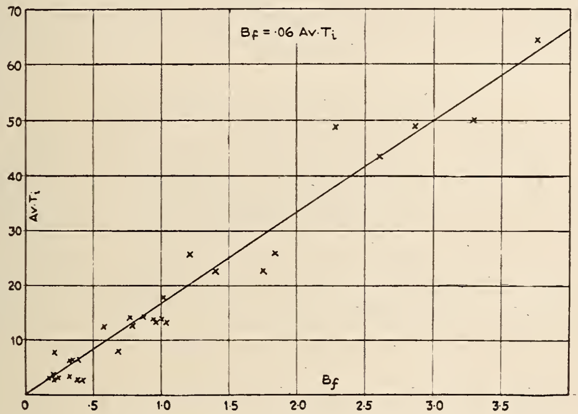

FIG. 3. Curve showing relation between average transmission and flare brightness.

Table 2

B_i (Spot)	B_i (Background)	Av T_i (for whole frame)	B_e (Spot)	B_e (Background)	B_f (Spot)	B_f (Background)
0.489	3.13	3.08	0.724	3.35	0.23	0.22
14.7	13.19	13.2	15.74	14.15	1.04	0.96
0.487	14.19	13.9	1.14	15.05	0.65	0.86
15.23	13.78	13.8	16.23	14.72	1.00	0.94
13.64	12.41	12.4	14.12	13.10	0.48	0.69
0.483	6.46	6.35	0.810	6.81	0.33	0.35
16.73	4.60	4.83	17.12	5.02	0.39	0.42
0.20	24.99	24.5	1.60	26.54	1.40	1.75
15.36	2.92	2.96	15.69	3.11	0.33	0.19
0.20	51.04	50.4	2.28	53.90	2.08	2.86
0.476	25.88	25.4	1.68	27.72	1.20	1.84

From the data in Tables 1 and 2, the curve Fig. 3 was plotted to show the relation between the flare brightness and the average transmission of the film. Apparently the rate of increase of flare brightness with transmission is linear for the two types of subjects so far investigated. The equation of this line is:

$$B_f = KavT_i + b \qquad K = 0.060, \qquad b = 0$$

Since this line passes through the origin, $b = 0$.

The value of K is indicative of the quality of a projection lens from the standpoint of flare. It is believed that other lenses of this type, i. e., with six glass-air surfaces, will have about the same value of K.

Goldberg has expressed the flare-forming quality of photographic objectives as "specific brilliancy." He defines this term as the logarithm of the ratio

$$\frac{\text{brightness of surrounding area}}{\text{brightness of reflected light over a black body}}$$

This value should be approximately equal to the logarithm of the reciprocal of our value K. For a series of photographic objectives measured at F/6.8, Goldberg finds values of specific brilliancy ranging from 1.2 for a four-component uncemented anastigmat to 2.2 for a single component landscape lens. For the three-component anastigmat which most nearly approximates the type of our projection lens, he finds the specific brilliancy equal to 1.5. $\text{Log}\ \frac{1}{0.06} = 1.22$ would be the specific brilliancy of our lens, which indicates that it would be somewhat worse than Goldberg's three-component anastigmat from the standpoint of flare formation. Since Goldberg's data also show that the effect of flare becomes worse as the aperture increases and since our lens had an aperture of F/2.1, the agreement between our data and Goldberg's is not bad.

Uniformity of Distribution of Flare Brightness

The value of B_f in the foregoing expression, $B_f = KavT_i$, with a given lens is supposed to be dependent only upon the *average* transmission of the projected picture and not upon the transmission of areas immediately surrounding the spot being measured. In other words, the flare brightness according to our expression is uni-

[4] Loc. cit.

form over the entire screen. More evidence must be gathered before we can say with certainty that this is true, but a careful analysis of all our available data has failed to show any definite correlation between the amount of flare brightness and the brightness distribution of the image being measured. Goldberg[4] has found that even for camera images the effect of the reflected or flare light originating from bright surfaces extends rather uniformly over the entire image field—in his case 30° from the optic axis, a considerably larger field angle than the 13° with which we are concerned. In the case of a projection lens, where the image distance is enormously greater and the flare images are consequently further out of focus, it is not surprising to find a uniform distribution of flare brightness.

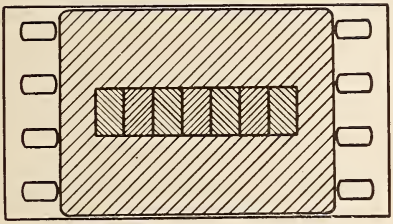

FIG. 4. Arrangement of areas in test frame.

Prediction of Screen Contrast from the Characteristics of the Positive Image

The data resulting in the curve Fig. 3 were obtained with elementary types of projected images. Let us now see with what degree of accuracy we can predict the effective brightness values for a slightly more complicated type of subject. A set of elementary "pictures" was made up as illustrated in Fig. 4. A strip containing seven different densities occupies the center of the frame. Masks of various densities can be placed over the frame leaving the strip uncovered in order to vary the value (avT_i).

Photographic contrast is usually expressed as the slope of the Hurter and Driffield characteristic curve[5] $(dD/d\ log_{10}E)$. When the ideal photographic densities of the areas of specimens (see Fig. 4) are plotted on density/log E co-ordinates, the solid lines drawn in Figs. 5 and 6 are obtained. In plotting these curves the log E value

[5] Hurter and Driffield papers, Jour. Soc. Chemical Industry, May and July, 1890.

is determined from the negative from which the positives were printed, and the value of D_i was read with the pinhole mask on the motion picture densitometer ($D_i = -log B_i$). But the value of ideal density will be greater than that of effective density because of added flare light. Values of D_e can be calculated from the corresponding values of D_i if the average transmission is known.

$$D_e = -log(B_i + B_f) = -log(B_i + 0.06 av T_i)$$

Values of D_e calculated in this way are shown as broken lines in Figs. 5 and 6, and the observed values are shown as circles or crosses.

It might be of interest here to summarize these results showing the effect on the density scale and on the extreme contrast value of the projected image.

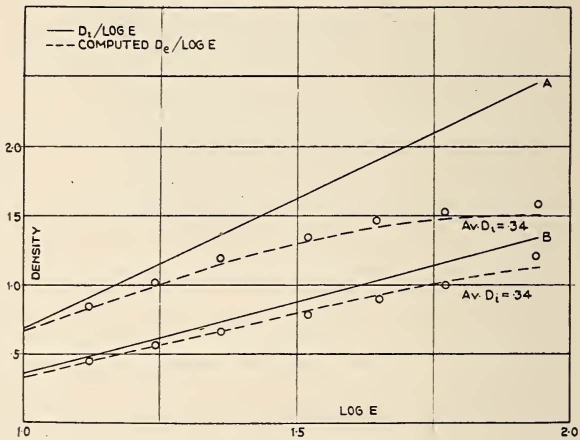

Fig. 5. Comparison of reproduction by the film and by the screen image.

Table 3

Fig. No.	*Av* D_i	*Ideal Density Scale* ($D_i max - D_i min$)	*Effective Density Scale* ($D_e max - D_e min$)	*Ideal Contrast* $\frac{B_i max}{B_i min}$	*Effective Contrast* $\frac{B_e max}{B_e min}$
5a	0.34	1.54	0.68	35.6	4.65
5b	0.34	0.86	0.69	13.8	5.02
6a	0.30	1.34	0.78	21.9	6.02
6b	0.64	1.34	1.02	21.9	10.51

When the picture is of low average density, the effect of lens flare on contrast is very severe. With a subject such as a seascape, close-up views of white buildings, or bright land-scapes containing a large amount of sky, the ideal contrast may be reduced to one-half or one-third of its value.

The curves in Figs. 5 and 6 were derived from positives made in such a way that all the densities lie on the straight line portion characteristic curve of the material. This is the necessary condition for precise proportionality between the brightnesses of the screen image and the brightnesses of the object reproduced. It will be noted that the effective curve of screen quality which represents the logarithm of the brightness of various areas in the screen image as a function of log exposure; and hence of log of object brightness, is no longer a straight line but definitely curved.

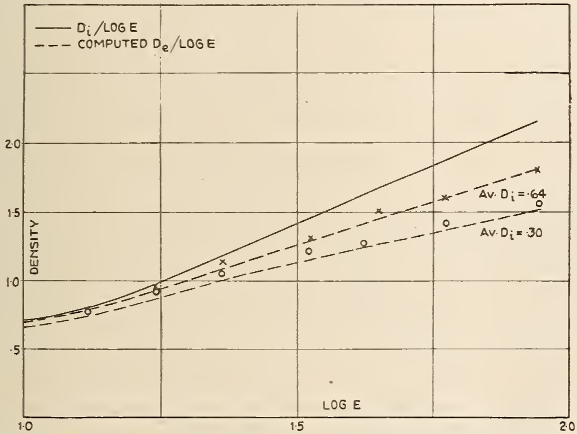

FIG. 6. Comparison of reproduction by the film and by the screen image.

The effect of lens flare on the quality of the screen image when the entire available density scale of the positive is utilized is illustrated in Fig. 7. The curve designated as *A* is the usual sensitometric characteristic of a positive material obtained by plotting density as a function of log exposure. Now, by using the numerical value of *K*, which has been determined in this work, and assuming a relatively low average density for the picture being projected, the curve *B* was computed. It will be noted that in case of curve *A* the relation between density and log exposure is a straight line between the points marked *a* and *b*. The corresponding range of the screen image is far from a straight line, thus showing that the lens flare produces a marked distortion of tonal reproduction. It should be noted also that the presence of the lens flare sharply limits the maximum black which can be obtained on the screen. It is customary in practice to attempt to compensate for loss of contrast due to lens flare by increasing the time of development in making the positive, thus increasing the slope of the straight line portion. It is evident from an inspection of Fig. 7 that, while this procedure is undoubtedly of benefit, it can not restore the straight line condition existing in the positive characteristic. As stated previously, in computing *B*, Fig. 7, a rather low value of average frame density was assumed. In case the average frame density is high, the distortion introduced by lens flare is appreciably less than as

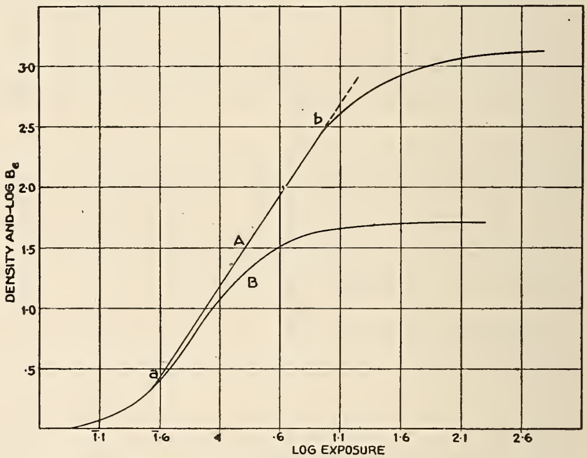

Fig. 7. Curves showing effects of lens flare upon the characteristic curve of a positive material.

indicated by Fig. 7. Many cases in actual practice exist in which the average frame density is low, and hence Fig. 7 represents a condition which frequently occurs in practice.

The material which has been presented is a preliminary report on the subject, and subsequent investigations may necessitate a modification of some of our present conclusions. Refinements in the apparatus permitting of greater accuracy and making possible measurement over the whole field of the lens instead of merely on the optic axis are being made. Measurements with various lenses and different types of subjects are proposed, and the results will probably be repeated in future communications.

Conclusions

1. The data obtained indicate that the screen brightness due to flare is directly proportional to the average transmission of the projected positive.

2. The numerical value of the screen brightness due to flare expressed as a decimal part of the average screen brightness based on the average ideal transmission of the positive may be used to characterize the quality of the projection lens from the standpoint of flare formation.

3. By using this lens constant, it is possible to compute the effect of flare upon the contrast characteristics of the projected image. The results obtained by computing the distribution of screen brightness by this method check very well with the actually observed values.

4. The effect of lens flare on quality of tone reproduction is to warp the shape of the reproduction curve and depress the contrast.

DISCUSSION

Mr. Palmer: There seems to be a general impression among cameramen that some of the flare could be removed by using a color filter in front of the lens, and I assume from what I have heard today that that is not true, but I should like to hear what Mr. Tuttle has to say on that.

Dr. Sheppard: There are one or two points I should like to bring up here with regard to the possibility of compensating for the effect that Mr. Jones and Mr. Tuttle have dealt with. I should like to ask them whether they could indicate the degree in which this compensation could be extended over the elements of the whole assembly of operations. In the first place, apart from lens design, there is the choice of illumination of subject, so that this warping of the characteristic curve could be compensated for in advance. The next point is the possibility of choosing the characteristics of the negative emulsion so that help may be afforded in that connection. Then, as to the positive film, one condition would seem to be that if the maximum black could be raised higher than generally regarded necessary, a considerable compensation might be brought about. The effect of development in the case of positives has been referred to by Mr. Tuttle, but it would not be possible if the maximum black is not already somewhat higher. I think it would be of special value to us if we knew the degree of compensation which may be anticipated by non-emulsion factors and emulsion characteristics respectively.

Dr. Hickman: What is the actual magnitude of this flare effect as compared with the known degrading of the blacks on the screen by the reflected lights in the auditorium, particularly the orchestra? As has been pointed out, the effect of flare is very dependent on the total amount of light transmitted by the particular frame. Where the subject is in a low key the degradation from lens flare is small, whereas that from general theatre illumination is important. With subjects in a high key the reverse would seem to be true. For the benefit of myself, who is not familiar with this work, and many others here who do not extract the exact practical significance from such a valuable piece of research, I should like to ask the relative importance of the flare on the screen from the two sources, lens, and auditorium.

Mr. Tuttle: With regard to the effect of color filters, of course, none of this work has been done with photographic objectives, and so our answer to that question is somewhat limited. However, I think that the general impression that color filters decrease the flare in lenses is an error. The added filter surfaces would, of course, increase the effect, which is dependent upon the number of interfaces giving opportunity for reflection.

The increase in brilliancy which sometimes occurs when a filter is used with a photographic objective is not due to a decrease in flare but is due partly to better color correction and partly to the more accurate focusing which can be accomplished when a filter is used.

With regard to Dr. Sheppard's question, we are hoping, of course, to solve some of the problems by judicious selection of material. I think the use of a negative emulsion of a different type may help in the solution. For instance, we have many negative emulsions with two straight line portions, and if we could adjust these to compensate for the loss by flare, a possible remedy would be offered.

We cannot say yet what possiblities there are in improved lens design.

Dr. Hickman's question of the relative amounts of the two effects I will refer to Mr. Jones.

Mr. Loyd Jones: Answering Dr. Hickman's question, I wish to point out that, as stated in the introduction, this paper deals specifically with a single factor of the complete tone reproduction problem. It is quite impossible in one paper to deal with the entire subject with its many intricate relationships. We have some fragmentary data relating to the effect of scattered room light on the contrast of the screen picture. Such data, however, does not seem to be appropriate to the subject matter of this paper, and therefore we have not quoted any quantitative values. If the picture being projected has a high average density, the degradation of contrast due to lens flare is relatively small, while under such conditions the effect of scattered light in the theatre is most pronounced. On the other hand, if the average density of the picture being projected is low, the effect of lens flare is a maximum, while in this case the effect of scattered room light is small. This follows from the fact that the absolute value of scattered room light is constant relative to the average density of the picture being projected. It will be seen therefore that the scattered light in the theatre becomes of importance only when the projection lens flare is a minimum. We have made measurements which show that the light scattered from the orchestra may in the case of a relatively dark picture produce as much or more lowering of contrast than can be attributed to lens flare. By careful treatment of the music stands and by proper arrangement of these stands, this, however, can be cut down to a negligible value.

I should like to say a few words also relative to the elimination of the lens flare by use of filters. All of the scattered light composing lens flare is of the same spectral quality as that emitted by the source used in the projector. This follows from the fact that the scattered light is due to reflection from glass-air interfaces. Such reflection is non-selective, so that it seems quite hopeless to attempt by using any sort of selective filter to eliminate this scattered radiation. It is possible that the idea of the beneficial effects of filters for this purpose comes from a consideration of atmospheric scatter or haze. In the light scattered by the atmosphere the shorter wave lengths predominate. That is, we say the atmospheric haze is blue. Now, in taking pictures, if a red or yellow filter be placed over the lens, this blue scattered light is eliminated and the image formed on the photographic material is limited to the longer wave-lengths. Thus, in elimination of the atmospheric haze selectively absorbing filters are of great value. The same argument, however, does not apply to projection lens flare, and since the addition of a filter necessitates the introduction of two more glass air interfaces in the system, it would probably actually contribute toward increasing somewhat the projection lens flare.

Considering the question of compensating for the loss of screen contrast by increasing the available maximum density in the positive material, it does not appear that such procedure offers any advantage. The present positive materials have available maximum densities of 4.0 or 5.0. It is impossible in practice of course, to utilize these extremely high densities. Even if the positive used in the projector represents the deep shadows of the picture by portions of the film that are absolutely opaque, the lens flare is of such magnitude to increase the screen brightness as to interfere seriously with tone reproduction. The case is similar to that of obtaining extremely low reflecting power high densities in the case of printing papers. The density in this case is limited by surface reflection factors rather than by the mass of silver in the emulsion. There is little doubt that something can be accomplished toward producing more correct tone reproduction by careful selection of the positive density-exposure characteristic. It is probable also that some improvement can be accomplished by a careful consideration of the projection lens curvatures and their relative positions with respect to each other. As a matter of fact, there are many factors which must be considered in any complete treatment of this problem. This paper does not purport to be a complete treatment, and we have only attempted to present a few preliminary data. Many of the other factors involved are at the present time being investigated, and in a future paper we hope to present more complete information which will undoubtedly answer many of the questions which have been raised in this discussion.

Mr. Capstaff: I might supplement Mr. Jones' remarks regarding the effect of the use of filters in cutting down lens flare. A year or two ago I made some measurements, not on projection, but in the camera to see what effect flare had in color work on color rendering. The use of a filter increases the flare because there are two new surfaces to reflect light, and in addition it is impossible to make gelatin filter film which does not scatter slightly. One of the most interesting things that I got out of the work was that the amount of flare in color work when you are photographing through two or more filters will differ with the color of the subject; that is to say, if you have a subject of large red areas, for instance, you get the full value of the flare in the red filter negative and much less flare through the green filter. Similarly, you get similar difference in subjects made up mainly of green. This seriously disturbs the color rendering.

A NEW CINEMATOGRAPH FILM FOR A LIMITED FIELD*

THE PATHÉ Cinema Company wish to announce a film termed Pathé-Rural having the substandard dimensions (17½ mm wide) shown in Fig. 1. The advantages of a width of 17½ mm are evident. Not only can the film be slit from the raw film regularly produced by the photographic industry, but the cost of production is lowered by the possibility of using existing equipment for making the new film; indeed, in the Pathé factories, perforation, printing, and development are carried out on 35 mm film, the slitting then producing two identical Pathé-Rural films.

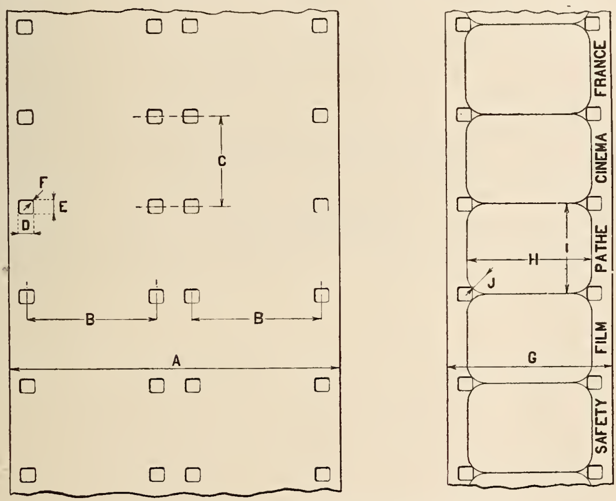

Fig. 1. Dimensions of Pathe-Rural Film.

The images measure 9-½ mm by 13-½ mm, the projector gate limiting the projected image to 9 mm x 13 mm. The shape, number, and size of the perforations have been very carefully studied, and those adopted suit all the requirements. The pitch of the perforations, equal to the height of the images, is exactly twice the perforation pitch of standard film, in this case also meeting the re-

* Abridgement of Communication made on February 10, 1026, to the Cinematograph Section of the French Photographic Society by the Pathé-Cinema Company.

quirements that a film even though new should in its dimensions correspond to multiples or submultiples of those already used for the standard.

The Pathé-Rural film thus contains 105 pictures per meter (32 per foot), and the reel of 150 meters (500 feet) exactly corresponds to a 300 meter (1000 feet) reel of the normal film. For the same speed of projection, the strain on the Pathé-Rural film passing through the projector is, as result of its smaller size, only a quarter of the strain on the normal film. For this reason, a narrow film can be made on a finer and weaker support, the thickness of the Pathé film being fourteen thousandths of a centimeter, of which twelve thousandths are those of the support made of cellulose acetate. In the Pathé-Rural projector such a film can be used a thousand times without apparent wear. The 500 foot reel weighs barely 500 gms. (1 lb. 2 oz.), while for the same projection time a reel of corresponding length of the normal film exceeds 2 kgs. (4-½ lbs.) in weight.

In recent years, other narrow films have been produced, one resulting from cutting the standard film, perforated, down the middle, while the other is of a width of 16 mm and carries images 10½ mm x 7½ mm with an area of 78 square millimeters. Compared to the latter film, the image on the Pathé-Rural film, which is of practically the same width, is 60% greater, measuring 126 square millimeters.

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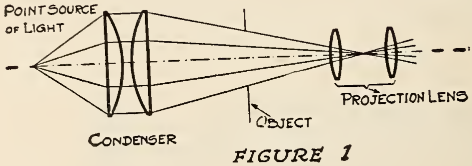

FIGURE 1

The first diagram represents the ideal condition that would result if there were available a "point source of light" and if the condensing lenses were perfectly corrected for spherical aberration.

The second diagram shows what the results would be with a theoretical "point source of light" and ordinary condensers.

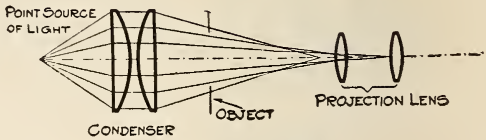

FIGURE 2

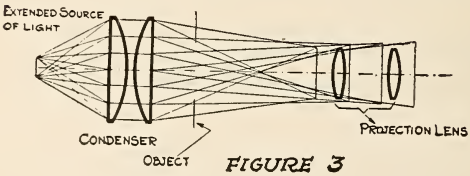

FIGURE 3

The third figure indicates the condition found with the usual type of condensing system under actual operating conditions. (Rays of light from different zones of condenser imaged in widely separated planes).

The last figure represents the condition found with a Bausch & Lomb CINEPHOR Condensing System. (Rays of light from all zones of condenser imaged approximately in one plane).

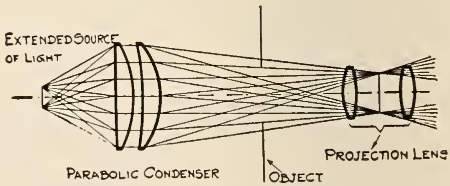

FIGURE 4

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OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

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MEETING OF MAY 3, 4, 5, 6, 1926

WASHINGTON, D. C.

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OF THE

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Number Twenty-six

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FILM MUTILATION*

JOHN M. JOY†

THIS investigation was first planned and put into operation by Mr. Courtland Smith and Mr. Pettijohn of the Motion Picture Producers and Distributors of America, Inc., and may be considered in part as related to an investigation which is still going on as to the value of certain methods of processing or treating a positive print for the purpose of adding to the life of the film and increasing its resistance to scratching and wear and tear.

Inasmuch as some efforts had been made at one time by the Atlanta exchanges to eliminate film damage it was decided that the Atlanta exchange center and the exhibitors receiving pictures from this point would be a preferred location to make an investigation

Method of Investigation

The territory covered by the Atlanta District consists of Georgia, Alabama, Florida, East of the Tennessee River in Tennessee, and some territory in South Carolina. United Artists distribute to about eight states including those given above.

Approximately five hundred theatres in Georgia, Tennessee, Alabama, and Florida receive films from Atlanta, possibly three hundred more are reached in other states to which United Artists ship and which are not covered by all of the other exchanges in the Atlanta District.

Preparatory to making a survey of this territory, the Atlanta Film Board of Trade was requested to have each member of the Board report the name of every theatre from which torn or mutilated film was received during a period of thirty days.

Visits were made to each of the exchanges for the purpose of noting the condition of film as it was returned from the different exhibitors. Considerable time was spent in the inspection room of the exchanges, particularly where an unusual amount of damage

* This paper is based on a report made to the Motion Picture Producers and Distributors of America, Inc., 469 Fifth Ave., New York, N. Y. on the damage to motion picture film prints supplied to exhibitors from distributing exchanges.

† Electrical Engineer, New York, N. Y.

had been reported. In this way it was possible to obtain first-hand information as to the exact condition of the film as it was taken from the shipping cans.

By talking with the chief inspector a very good impression was obtained as to the methods used in inspection, whether or not they were up to the standard which should be employed, and whether suggestions could be obtained for improved methods. Often several thousand feet, foot by foot, of a subject were followed through with an inspector. In other cases the chief inspector would point out defects in the film requiring repairs.

Investigation was also made of the shipping methods, the way the film was handled, the condition of reels, shipping cans, condition of the rewinding machines, storage vaults, splicing machines, and in fact all details which enter into a thorough and conscientious inspection and repair of all film received at the exchanges.

Practically all of the exchanges use a uniform method of inspection, although in many of the exchanges there is a difference in some of the details of their method and equipment. The inspection departments of the exchanges were visited several times. The visits to the inspection rooms were made without previous notice to them, so that probably the average daily condition was found.

During the visits to the exchanges many cases of film damage were observed in addition to those already reported in writing to the secretary of the film board. In some instances it was possible to inspect the actual subject damaged and trace its history from the exchange to the exhibitor and back again. In some cases, as will be noted later, the exhibitor's side of these specific cases of damage was investigated while the case was fresh in mind.

It was very difficult to find any exhibitor who would admit that his theatre had damaged an inch of film. After about two weeks of continued visits to the inspection department, it was possible together with previously reported cases to separate and compile under various heads the principal kinds of damage done.

This information obtained, it was decided to visit a certain number of theatres. These were selected with the ideas of grouping as to

(1) Continuous offenders

(2) First-class theatres in larger cities having 1,000 seats or more

(3) Small theatres in the small country towns.

It was thought that close study of smaller types of theatres with surroundings approximately the same might disclose certain conditions of apparatus or handling of the film, which would make it possible to classify some of the causes for certain kinds of damage to films. It would be reasonable to conclude that if the mutilation of film coming from similar types of theatres in remote locations was of the same nature, then the primary cause was the same. It was only by following through some such pre-arranged plan of investigation that it was possible to obtain facts of practical value.

Mutilation of Film Classified

By grouping together the written reports gathered by the Atlanta Film Board of Trade from the twelve different exchanges in Atlanta over a period of about thirty days and supplementing this with the result of investigations and talks with the inspectors of the different exchanges, it was possible to classify certain damages which occurred most frequently and which are fairly representative of the mutilation of positive prints under the average conditions of commercial handling or exhibiting.

The following summary shows the different kinds of mutilation encountered:

Damage Reported

Total number of complaints reported	52
Reported, but kinds of damage not specified	6
Total	58
Sprocket damage reported	38
Nature of damage not specified (probably sprocket damage)	6
Total	44
Badly scratched emulsion	8
Mutilation for tail end signal	5
Fire damage	1

Relative to the above specified complaints, additional information was recorded on cards. These cards show the producing company complaining, the name of the theatre, town, and state, name of picture, and other details. Some reports were noted on the cards furnished by chief inspectors. There were numerous cases in which the same exhibitor was reported by different distributors and often several times.

Causes of Film Mutilation

An analysis of the above reveals that, taken in the order of their most frequent occurrence, the following types of film damage occur:

1. Sprocket damage, which includes torn sprocket holes, strained corners of the sprocket holes, holes and tears caused by the film jumping off the teeth and riding over the tops of the sprocket teeth.
2. Scratches.
3. Mutilation of the end of the film for signal purposes.
4. Fire damage to film.

Sprocket Damage

The subject of sprocket damage from all indications is the most serious one. Many conditions could directly produce this damage and various other factors contribute indirectly to this kind of mutilation. Some of the causes of sprocket damage to film are classified as follows:

1. Improper adjustment of the tension shoes.
2. Improperly made or poorly made splices. This matter of splicing is of great importance and bad splices are the source of much damage to the film.
3. Damaged film reels. A great many badly damaged reels were found in use by some of the exchanges.
4. Badly notched sprocket holes.
5. The use of old and brittle film which should be taken out of service.
6. Overspeeding. New prints are most liable to be affected because "green" emulsion offers more resistance during its passage through the projector.
7. The fact that exhibitors permit projector parts to become so badly worn that breaks occur. This can be prevented by renewing parts more frequently.
8. Defective mechanism of the projectors. Improper lubrication and under cut or worn intermittent sprockets. Dirt on the intermittent sprocket produces jumpy pictures on the screen, and in extreme cases causes the film to ride the teeth. Worn intermittent

sprocket teeth may make the picture unsteady, injure the edge of the perforations, and also have a tendency to make film climb the sprockets.

Too much gate tension causes unnecessary wear on the intermittent sprocket teeth and edges of the sprocket holes and will eventually lead to serious damage of the film. If the teeth become

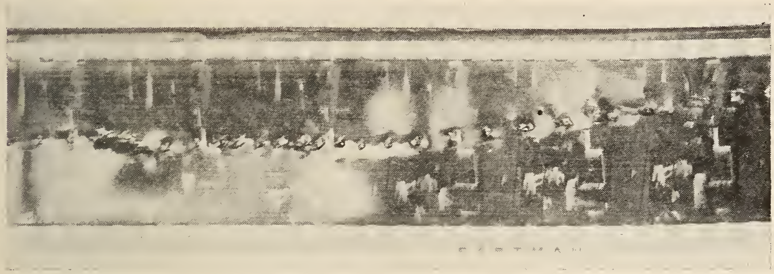


FIG. 1. Sprocket ridden film.

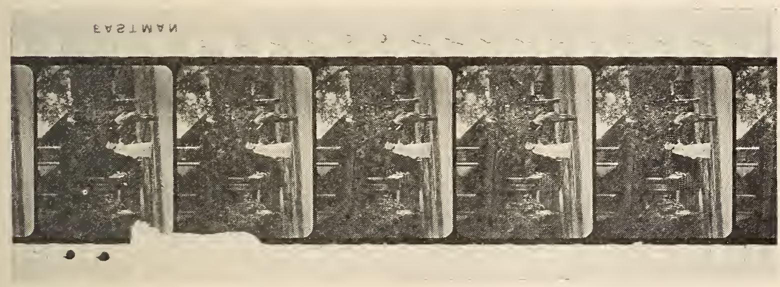


FIG. 2. Torn sprocket holes.

hooked or undercut, this is more serious and if projection is speeded up the strain may be enough to crack the sprocket hole corners. When this is once started, the life of the film becomes very short.

Scratched Mutilation

Scratches appear on the emulsion side sometimes as three or four lines running the entire length of the reel. These scratches vary in width and number. They collect dirt and appear on the screen in the form of ropes and streaks which are commonly referred to as "rain." These scratches destroy the quality of the picture.

In several cases dirt, oil, and grit mixed together were found on the upper and lower valves. The film passing through this would collect the grit and undoubtedly would be scratched by it.

It is well known that during projection some of the emulsion is removed and deposits on the face of the tension shoes. This forms as hard spots or points and causes scratching. This deposit is also found on the aperture plate. Of course, this deposit of emulsion should be removed in the proper way. Often it is scraped off with a screw driver, which leaves the surface of the plate and shoes in a roughened condition, and this would cause scratching of the film.

Imperfect upper magazine valves are responsible for some scratched film especially when the projection speed is high. The film may be scratched from careless rewinding by the exchanges and by the exhibitor. Occasionally motor rewinders in projection booths run too fast, and if the reels are in bad condition, the films are apt to be scratched.

Nearly all exhibitors rewind onto their own projection room reels, which hold 2,000 feet of film. Sometimes these reels are not kept in proper condition, the holes become worn, and the reels then wabble, possibly rubbing against the sides of the magazine. The reels may also have their sides bent and the edges of the flanges serrated, which condition does not permit the film to run off smoothly and freely.

Film reels should be examined frequently and any defects corrected. The same troubles, of course, occur when the film is wound back on to the exchange reels. Many exchange reels were observed to be in a wretched condition, both when received by the exhibitor and when received back at the exchanges. All of these conditions contribute to causes which produce scratches on the film.

Signal Mutilation

There are various mutilations used to indicate to the projectionist when the end of the reel is approaching, so that he can change over to the other projector before the end is reached. There were several different schemes in use. A favorite in the South seemed to be the use of tin foil which forms an electric contact with other parts of the projector when the film reaches a certain point and thus rings an electric bell. Some projectionists punch holes in the film which are flashed upon the screen, and others scratch a number of crosses on the film which also show on the screen. All of these methods are a disgrace to the man who uses them and should not be permitted. To allow the entire film to run through and flash these crosses and punched holes and other things on the screen is certainly very crude work. The sprocket teeth collect the tin foil all over them, and this would cause film to jump the sprockets. Such practice may well be classed as a fire hazard and in many sections, at least in New York, would be considered a violation.

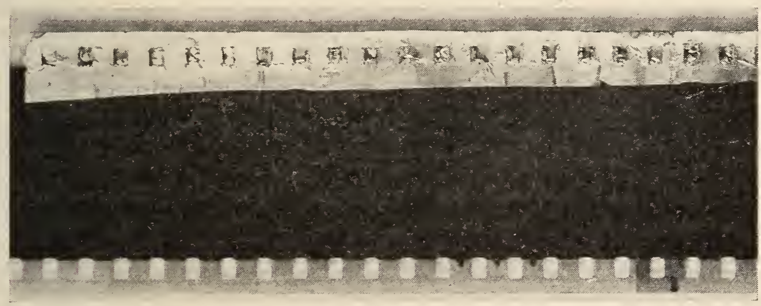


FIG. 3. Mutilation of film by pasting tin-foil on edges.

Undoubtedly the exhibitor should be held responsible for this kind of mutilation.

Fire Damage

Since there is but one case recorded of an exhibitor burning up film, and as this does not come directly under the classification of mutilation, it will be dealt with later.

Film Inspection Systems Used by Exchanges

New positive prints are received directly from the laboratories. The prints are shipped to the exhibitors from the Atlanta exchanges both by express and parcel post. Reels are enclosed in standard shipping cans. Both the square and eight sided cans are used. Some shippers believe that the eight sided can is much stronger and more durable.

The new positive prints when received from the laboratories are inspected and wound onto the regular reels used by the exchange.

Some of the exchanges grease the edge of the film by wiping a thin layer of vaseline over it. This helps to lubricate new film when it is first run. Other exchanges have not had good results from this method.

The daily shipment of prints received from various exhibitors is inspected. Each reel is examined by rewinding it from the reel received to another one. During this rewinding the inspector looks carefully for bad splices, broken or strained sprocket holes, and also notes if the print is badly scratched. Some exchanges are much more thorough than others. The prints are often rewound much too rapidly to permit of a thorough inspection.

The film is held and passed through the fingers of the inspector, who is able to feel any breaks, torn holes, or bad patches provided the film is not run too rapidly. If the inspector detects a bad splice, it is cut out and a new one put in. The splices made by the exchange inspectors were generally found to be carefully done. If the print has been badly sprocket damaged over a considerable length, that portion is cut out and replaced. In some cases a whole reel is thrown out on account of damage.

The inspectors are constantly finding one or more sprocket holes which are torn and have to be cut out necessitating the making of a splice. If the print has been in service for a long time, after perhaps 50 or 60 runs, it becomes somewhat brittle, and a great many more torn holes are usually found until finally the print becomes so brittle around the sprocket hole edges that it is taken out of service.

Often some of the faults in the film are passed over and not repaired because an inspector is compelled to rush through the inspection in order to turn out a certain number of reels per day. Some reels require much more time than others for inspection and repair. It has been found that an inspector can turn out on an average from 35 to 50 reels a day and give them thorough inspection and repair.

In most of the exchanges quality of inspection is a first consideration. If a greater number of reels are required to be inspected in a day than can be efficiently done by the regular staff, more inspectors are put on instead of trying to make an inadequate force do the work.

If the inspector is in doubt as to whether or not certain portions of a film should be cut out, she reports to a chief inspector and sometimes the matter is taken up with the manager in order to decide whether it is advisable to take a film out of service. In some of the Atlanta exchanges many prints were being taken out of service each day, which would indicate that the inspectors are aware of the importance of not trying to run old prints too long.

Rewinding Machines

The machines used for rewinding are hand-operated and are practically standard throughout the exchanges. Some improved rewinding machines are being introduced in a few of the New York exchanges. They are provided with a quick means of stopping the reel by a brake applied by the operator's knee. Those using this apparatus speak favorably of it. It certainly would avoid stopping the reels by hand. Often the hands are cut from the sharp edges of damaged reels.

Splicing Machines

All of the Atlanta exchanges are using some mechanical method for making splices. The splicing machine most universally used is a hand-operated type. This machine is provided with means for cutting the film at the proper point determined by gauge pins which insure accurate frames. When properly used, these little machines seem to produce uniform splices. However, care must be used in cleaning the emulsion from the film, applying the cement, and giving sufficient pressure and time to cement the joint together so that it will be strong and will hold while in service.

Another machine in use is more simple and is not provided with any means of cutting the film. Some of the smaller exchanges use this machine and consider it quite efficient. It would be well adapted for every theatre projection booth.

One machine which is operated by hand levers is semi-automatic in that it scrapes the emulsion, brushes on the cement, and another motion applies the pressure. This particular machine, which has been tried by some of the exchanges, has not given reliable service. It frequently gets out of adjustment.

Another type which is more completely automatic and is partly operated by foot power is being tried out. This is quite an expensive machine and is provided with an electric heating pad, the purpose of which is to dry the cement more quickly. The joints are not quite so wide as those made by other machines, and there is a difference of opinion as to whether or not this machine makes better joints than the hand machine. It is claimed that a splice can be made much more rapidly with this than with any other machine.

An Inspector's Observations of Conditions in Exchanges

It has been charged by some that the exchanges make only the most superficial examination of film and that they even send out to exhibitors film which has not been inspected at all. They have been accused of sending film with loose splices, mis-frames, strained and torn sprocket holes, and with the emulsion scratched and covered with oil. This is often times coupled with an insinuation that the exchange deliberately does this to avoid film inspection and repair work and throw these on the exhibitors. It has also been claimed that the exchanges do not detect anything except the very worst faults, as, for instance, a long stretch of torn sprocket holes or a patch almost dropping apart.

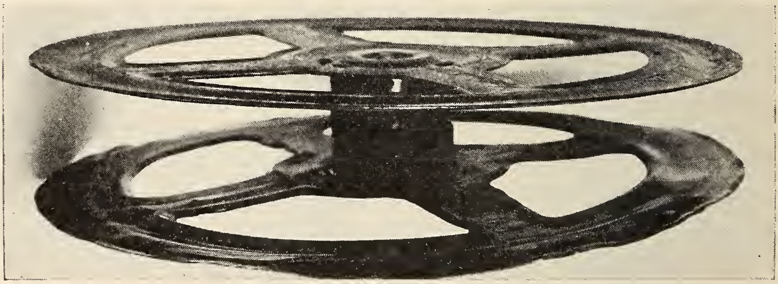


FIG. 4. Sample reel found in service. Note bent and twisted rough edges. Sides are spread apart in one place and are compressed on opposite side. Sides are also loose on hub and ready to fall off.

It can be definitely stated that nothing whatever of this kind was found in any of the exchanges visited at Atlanta.

Some of the exchanges use enough time to inspect a reel and consequently do it more thoroughly. The principal criticism that might be made of exchange inspection is that sometimes the film inspectors are compelled to wind at high speed in order to rush out a day's shipment. Under such conditions some minor faults might be overlooked.

Some other conditions observed which might lead to trouble are the following:

1. *Rewinders out of line* with a loose fitting reel shaft which would cause even a new reel to wabble.

2. *Reels in bad condition.* Bad reels were numerous and were found to be bent and the edges sharp and rough; the sides were crooked and would lock the film so that it required more strain than necessary to pull it off the reel. In other reels the sides were

separated so much that if used in the projector magazine they would rub on the sides.

The exchanges, however, are constantly throwing out bad reels.

Unnecessary roughness and carelessness in handling and throwing the film cans around probably is responsible for the condition of some of the reels.

3. *Bad Splicing.* It may be said in general that the exchange inspectors use care in making splices. They have to be made quickly, and inspectors become quite expert in making these patches. Of course sometimes they become careless, and occasionally a splice may not be properly made and does not hold. They are careful to detect and cut out old exchange patches which seem to be weak. In almost every case an operator's patch is cut out and a new one made. This is especially true of patches made by operators in some of the small town theatres.

An Inspector's Observation on Conditions in Theatres

The following theatres and projection booths were seen at Atlanta and interviews obtained with the managers: Howard Theatre, Rialto Theatre, Metropolitan Theatre.

Projection rooms of these theatres had first-class equipment which was kept in good condition. Projectionists were all experienced men. They invariably used the cue system as a change-over signal. They agreed that mutilation of film for signal purpose should be stopped. Booths at all of these theatres were kept in first-class order and all fire precautions attended to. The projectionist at one theatre claimed that weak patches were sometimes received from exchanges but were usually detected and repaired because they rewind on to 2,000-foot reels. He showed some sample patches which had been cut: apparently they were exchange patches. Also, some scratches were noticeable when the film was projected on the screen. In addition, he cut one or two notched holes and respliced the film. The projection machines used here required very few repairs in the last year.

The principal criticism at one theatre was the high projection speed. The projectionist stated that on account of the holiday week, they had an unusually long program. They were running about 14,000 feet of film and two or three extra musical numbers in a two hour show. In one comedy the speed was so high that it was almost impossible to read the titles. Probably at times the projection speed was 120 feet per minute and averaged around 90.

The Exhibitor's Responsibility for Film Damage

If the exhibitor neglects to replace worn out parts and does not keep the equipment in proper adjustment, he is guilty of causing film damage.

That various parts do wear more than others and require replacement and adjustment to prevent damage are facts which have been definitely established. As an experiment, the Atlanta Film Board of Trade had for a period of several months an inspector who visited various theatres in Georgia, Alabama, and Tennessee where it was suspected that equipment needed repairs. Two tables were made up from records and reports of this inspector, who carried most of these parts with him and supplied them to the exhibitor when he thought a projector should be repaired. It is only necessary to group the data to conclude quite definitely that the number of parts which show the most wear and have been replaced in the greatest quantity are a measure of the conditions which cause mutilation of film. These may be grouped as follows for the Power's and Simplex Machines:

Repair Parts Supplied by Inspector

Simplex Projector		*Power's Projector*	
Part	*No. Used*	*Part*	*No. Used*
Upper Sprocket	22	Tension Shoe	35
Lower Sprocket	28	Int. Sprocket Roller	57
Int. Film Guide	32	Aperture Plate	48
Film Guide Holder	17	Guide Roller (Gate)	24
Lat. Guide Roller	6	Upper Mag. Valve	11
Film Trap Shoe	4	Int. Sprocket	22
Apr. Plate	5	Lower Magazine Valve	6
Int'm. S. Wheel	21	Top Roller	3
Upper and Lower Small Magazine Roller	16	Apron Lower	29
Int. Sprocket Stripper Roller	25	Take-up Sprocket	17
Upper and Lower Large Magazine Roller	13	Take-up Roller	9
Film Trap Pad	12	Top Sprocket	4
		Pin Cross	2
		Spindle	2
		Tension Shoe Spring	2

Pad Roller	5	Stop Screw for Gate	1
Lat. Guide Roller	16	Screws for Aperture Plate	2
Film Trap Door Shoe	19	Miscellaneous	20
Film Trap Door Shoe (right)	22	Total	294
Film Guide Spring	5		
Screw	37		
Int. Film Guide (outside)	6		
Int. Film Guide (inside)	6		
Miscellaneous	36		
Total	353		

The following is taken from the report of an inspector of theatre projection equipment in Alabama, Georgia, and Tennessee:

May 13th—June 16th, 1924

Theatres Visited		*Repairs Made*		*Repairs recommended and made by Owner*	
54	Alabama	6	Alabama	2	Alabama
3	Georgia	–	Georgia	–	Georgia
18	Tennessee	3	Tennessee	4	Tennessee

Equipment found in such condition that it could not be repaired:—Alabama 7.

Total theatres visited 75

Total number of theatres at which repairs were made or recommended to be made, or machines overhauled 42

Splices made by the Operators

Taking everything into consideration, information obtained from reports, conversations with inspectors at 12 different exchanges, exhibitors, operators, and other information, it is believed that bad splicing is directly and indirectly the cause of most film damage. Some of the operators make splices which are a disgrace, and although the exchanges try very hard to eliminate these during inspection, sometimes one or two may pass by and are then eventually the direct cause of sprocket damaged film or a fire. It is only necessary to note the photographs of a few of the operator's splices to be convinced that this condition is a fact. These samples are but a few of the many that are occurring all the time and are a source of constant trouble.

Film comes back to the exchanges pinned together, stuck together with gum, pinned with safety pins, and as shown in one of the photographs tied together with wire. Pinning the ends together with the pin points exposed is a dangerous practice. There are numerous cases of the hands and entire arm of an inspector

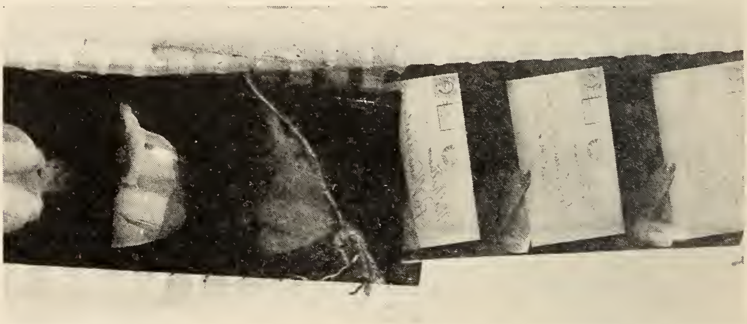


Fig. 5. Film spliced with wire.

being ripped open by these pins during inspection. Probably such splices are made because film breaks while being projected, and the quickest way to join it is used.

Fig. 6. Bad splice and signal punches.

Many cases were found in which splices made by operators did not have the emulsion scraped off at all before applying cement; in fact, this is quite a common occurrence. Of course, such splices have no strength whatever. Some operators seem to smear on plenty of cement and press the two ends together with their fingers without regard to framing.

Among the exhibitors, very few of the operators have any mechanical means of making a splice. The tools usually consist of a knife or a pair of shears and a bottle of cement. It is not to be expected that theatres would be equipped with automatic splicing machines, but a small cheap bench splicing block should be a part of every projection room equipment. At least this would help to eliminate many of the bad splices which operators make.

Speeding

Some small theatres make a practice of speeding. One small theatre in Alabama, called a "grind" house, would run off 7 reels in 45 to 50 minutes on Saturday nights. Speeding undoubtedly is responsible for film damage, the extent depending somewhat on the condition of the film. It also seems to be a rather difficult situation to control. It is practiced both by large theatres as well as small ones, probably more so by the large ones.

Summary of Findings

1. The monetary value of film damaged in the entire United States must be very large if the same proportion of mutilation exists as was found in the Atlanta District.

It is possible to make only a rough estimate as to the cost of damage caused by film mutilation. If we assume each exchange in Atlanta to average five inspectors, each turning out thirty-five 1000-foot reels per day, then $35 \times 1000 \times 5 \times 6$ equals 1,050,000 feet of film per exchange a week. At four cents per foot, the total value would be $42,000 and multiplying this by twelve, the total value of film handled by all exchanges in Atlanta per week is $504,000. If only a small percentage of this film is damaged, it is seen that the yearly loss is very large.

The damage cannot even be measured by what it costs to keep the film is repair (and this amounts to about $1,500.00 a week), because often a whole reel has to be taken out of service.

2. Taking all the facts into consideration, it is evident that because of worn and badly adjusted machines, exhibitors are generally responsible for the mutilation of motion picture film.

3. Exchanges sometimes may indirectly be the cause of film mutilation by allowing prints to stay too long in service, making splices which do not hold, using reels which are in bad condition and which should be thrown out, and winding the film at top speed so that faults are passed.

4. Of the various kinds of damage investigated, over 75% was found to consist of sprocket holes torn, strained, or otherwise mutilated by the sprocket teeth. The other damage consisted of some kind of mutilation for a change-over signal and scratched film.

5. The condition of the exhibitor's equipment is undoubtedly responsible for a large amount of sprocket mutilation.

This is due to the use of worn parts which should be replaced, faulty adjustments, and neglect in the care of projection machinery.

6. Bad splices are directly responsible for much of the film mutilation. Operators' patches are a constant source of trouble.

7. Bad splicing, pasting of tin foil on film for signal purpose, using old and brittle film which may break out and run off the sprockets, all help to increase the fire risk.

8. Running film through the projector at a high rate of speed will mutilate film, especially if the film is weak and the projector out of order.

9. Just a few theatres with faulty apparatus would be enough to make trouble in any district. Sprocket holes might be slightly strained but not sufficiently to be noticed, yet the next booker could not help mutilating the film. It is conservative to state that 40% of the theatres could be improved by having their projectors repaired and adjusted.

10. The public is no longer satisfied, even in the small towns, with a show during which interruptions take place because of film breaking or running off the sprockets. Bad scratches on the screen are no longer tolerated.

11. One fact stands out above the others as a result of this investigation. Every exchange manager in Atlanta strongly approves putting into operation at once a practical system which could be used as a means for reducing film mutilation.

One hundred per cent of the exhibitors talked with will aid any plan and co-operate in every way to help eliminate damage.

Both distributors and exhibitors were of the opinion that if the Motion Picture Producers and Distributors of America, Inc., or the Film Boards of Trade would stand back of some organized plan to eliminate film mutilation, a service of great value to all would result.

Conclusions and Recommendations Relating to a Plan for Reducing Film Mutilation

1. *Film Protecting Process*

Some method of treating film which will increase the resistivity of the emulsion to scratching or prolong the life of the film in any way is highly desirable. Several film protecting processes are under investigation, but definite recommendations are withheld until completion of the tests.

2. *Mutilation for Signal*

It is suggested that the entire question of providing a standard method which can be used as a signal for throwing over to a second projector be taken up with the Standards Committee of the Society of Motion Picture Engineers.

Elimination of the use of tin foil for signal purposes might be brought about by pointing out to exhibitors that this practice creates a fire hazard and could be construed as a violation of fire regulations. An inspector of the New York Fire Department who was inspecting a New York exchange, on being shown a piece of film pasted with tin foil, stated that he would consider it a dangerous practice.

3. Exchanges should constantly insist on the most rigid examination and be on the watch to see that carelessness does not enter into the inspection. It is important that damaged reels be thrown out when they are no longer in a condition to be used. It is not economy to continue to use prints which have become worn and brittle through long use.

4. *Subjects for Technical Investigation*

A. Improvements in reel construction.

B. Uniform methods of splicing, especially with a view to inducing all the theatres to use some simple and low cost machine.

C. Has the general use of high intensity sources of light in projectors anything to do with the cause of film becoming brittle in service?

D. Is there any serious shrinkage of the film produced by intense heat coming from high powered light sources which would be sufficient to sometimes cause the film to ride the sprocket teeth?

E. To what extent does excessive heating have an injurious effect on the life of motion picture film?

This entire problem is very complicated, and much work must be done by a properly equipped laboratory before any final conclusions of value can be drawn.

That brittle film may be caused by too much heat radiating from the light source of low intensity or reflector arcs is suggested from conditions actually found at some of the exchanges located in Washington, D. C., district and from other data relating to the use of high powered light sources.

5. It might be well to consider the appointment of a permanent committee selected from producers, distributors, exhibitors, engineers, projectionists, and makers of equipment. Such a committee would function as a clearing house for all information and suggestions relating to film mutilation

DISCUSSION

Mr. Hill: I would like to mention what has been done to prevent film mutilation by our organization. When the Army Motion Picture Service was first organized, we found it difficult to persuade the exchanges that we would take care of their prints, for film is fragile and the Army is very rugged. But the exchanges are now convinced, and their change of attitude has followed changes which we made in our equipment. Overspeeding was the most prolific source of damage, so our first move was to limit the projector speed to 80 feet per minute. We have adopted a film gate embodying a limited tension and are now investigating the take up tension with a view to adopting some automatic device which will preclude damage there. Our equipment is regularly inspected and overhauled, and in the very rare instances where film damage does occur, we make a special trip to the offending theatre to find the cause.

Mr. Edwards: I think from the remarks of the speaker he has overlooked something. The "punch mark" dates back to a very early period in the industry and now can only be done away with if the exchange carries a report card for each film, sends its prints free from punch marks, and promptly bills the exhibitor, say, $1.00, for each punch mark found on the returned film. The practice will stop in a week. Your can collect money from any man who willfully damages your goods. It is unfortunate but true that many people handling another's goods for only a short time, are apt to be careless with them, especially if they are rented. Their thougth is, "I should worry"; somebody else will have the film to-morrow. They are interested in to-day only.

With reference to the inspection plan, this worked very well where the inspector was competent and tactful. Unfortunately, the effectiveness of the inspection of the apparatus in the projection rooms was limited by the keen competition of the exchanges for the exhibitor's business. It was found that when the exhibitor was informed that he must spend money for needed repairs, he simply ignored the inspector's recommendations and took his business to an exchange where they were not so particular. It is quite true that the lack of minor repairs causes an enormous amount of film damage each day.

As to the methods of indicating "change overs" adopted by some exchanges, the remedy is as bad as the disease. I have found film coming into the theatre with a sticker label covering from 3 to 5 frames not at the change over point but from 50 to 75 feet from the end of the reel, which blocked out two-thirds of the picture on the screen. These should be promptly cut out as soon as the film comes into the theatre.

There is only one correct method of marking a "change over" cue; that is, to note the last title in each reel and the number of scenes that follow or the particular action of the players and make a "Cue Sheet." No marking of the film is necessary.

A suggestion to producers might be of value:—Place a thirty-six inch length of black dyed film ahead of the tail piece. "End of Reel One," etc., cannot show without warning on the screen.

As to damage by patching, only a few weeks ago we had to remove from a first run print coming into our theatre from a first grade exchange twenty-eight machine made patches before we could run it a second time. It was found that the scraping device attached to the splicer had, in addition to scraping the emulsion, cut into the base. All twenty-eight patches had broken edges. Each one was a fire risk.

If the exchanges were to get together, put their stock in first class shape, then say to the exhibitor, "You have valuable property of ours in your hands, and if you will not take care of it, you get no more service from the exchanges," I think the trouble would stop. This is drastic but some troubles need drastic remedies.

Another great source of film mutilation: Forty per cent of the reels used should never have been anywhere else but on the scrap heap. They are too light in weight, poorly designed, out of true, have weak hubs, and sometimes have no film retaining spring.

We get away from a lot of trouble in the better houses by having a "house set" of reels, and we let the exchanges have the film back on their own reels. We should never dream of running a show on exchange reels or, I should say, the excuses for reels which the exchanges send us.

Film mutilation can be lessened to a great degree by a little study on the part of the exchanges and a little more backbone in their dealings with the renter of film.

President Cook: I have been much interested in this paper and in the comments, because Kodascope Libraries has the same problems among the home users except that the average home users know nothing about making splices or repairs and next to nothing about the science of projection. We have found that the most prolific source of difficulty is in the splices, not because the film catches in the machine but because the splice breaks at the turn of the sprocket. The sharp turn made by the film around the small sprockets puts an enormous strain on the film at each end of the doubled portion. We make the splice very narrow and use the Bell and Howell automatic splicer in the laboratory and the Griswold in the exchanges. There should be one employee whose business it is to change all the cement every day in all the bottles. Is this true of the large exchanges?

Mr. Denison: I don't think it is; some of the exchanges are very careful about it, however.

President Cook: At the end of the day's work each inspector makes three splices, and these are placed on file and examined every day for several weeks so that it is possible to trace the results, which minimizes carelessness.

Mr. John G. Jones: How often are the perforation troubles due to poor sprockets?

Mr. Joy: We have not accumulated detailed data on this. Undoubtedly, trouble is caused by poor teeth, but this is principally in the small towns where the operator is not aware of the importance of it. In one town of 1800 inhabitants where the theatre was not much more than a cow barn the apparatus looked good on the outside. When I opened the magazine, however, I found a spoonful of dirt and grease on the upper magazine valve and the sprocket teeth were in bad shape. In talking with the boy of seventeen or eighteen years, who was running the machine, I found out that he had very little conception of it, except that he should get the film through somehow. I think these are the conditions that the experienced projectionist has got to consider and in some way transmit his superior knowledge down to these fellows in order to educate them and eliminate that sort of thing.

Mr. John G. Jones: What do you consider the average tension should be at the gate?

Mr. Joy: It is variable, but I have no definite figure on the tension. There are some cases where they don't rewind and use the exchanges' thousand foot reels; they put the warped reel in the magazine. Many times it bulges out and rubs on the side, and they put more tension on the take-up. That is an extreme case, of course, but such conditions make trouble for the whole system, because a shipment from that particular theatre might go back to the exchange where the damaged part might not be detected in inspection, and the film might go out to high grade theatres the next time.

All the theatres in the small towns, in Georgia, for instance, want good pictures. In one small town not far from Atlanta I was surprised to see pictures which had been on exhibition only a short time before on Broadway, N. Y. Towns of only five thousand inhabitants were showing these pictures. I asked the manager how he did it, and he said he had to do it for his people go to New York frequently. He needed pictures of good quality which were up-to-date.

Mr. Davidson: I want to second very strongly what Mr. Cook said with regard to film cement. We have had some experience in handling library films, and it is our impression that the cement made for NI film is not so good as that made for inflammable film and that it does deteriorate more rapidly. I may be wrong because we have not made detailed tests.

President Cook: In reply to that query, I may say that our experience having been almost entirely with NI film I do not feel competent to make an intelligent comparison. I do not think that the engineers as a whole have very much to do with NI film. They are almost all using—that is, the users under discussion are using—nitrate film. There is no question, I think, that with acetate film it is more difficult to maintain a permanent splice than with nitrate. It might be of interest for the research laboratory of the Eastman Kodak Company to investigate if they have not already done so. I suggest that the Chairman of the Papers Committee consider the matter of a paper on the durability of splices on nitrate and acetate film. Such information would be of great value.

Mr. Capstaff: The problem brought up by Mr. Davidson is one which is with us in the laboratory. There is without a doubt a difference in the splices made with acetate and nitrate film. It comes about because we have not found a suitable solvent for the base. With the acetate film, it is a cement; with the nitrate, you have a solvent of the base, and that is why you get into such difficulties with the cement and have to keep it in fresh condition. The solvents evaporate at different rates, so that if one is not careful to keep the cement in good condition, it makes a very imperfect splice. We are working on the problem and have hopes of getting something to make a stronger splice.

President Cook: I think Mr. Capstaff has answered your question better from the research side, whereas mine was the result of painful experience.

Mr. Ricker: Do you find that the film after three or four years' life is more difficult to splice? I had some trouble with this, and I switched from one cement to another and had the greatest difficulty. Sometimes film in the same reel will differ; you can't use the same cement for all of it. Some looks like the rest but is not, although it is all right when it is new.

Mr. Capstaff: That is quite true about the increasing difficulty one has in cementing the acetate base as it grows old. If you are caught at any time and must make a splice on the old film, you will find that if you abrade the surface with sandpaper, you can make a very strong splice on old film.

Mr. Ricker: Have you tried DuPont glue for the purpose?

Mr. Capstaff: We have tried everything we could lay our hands on but have not yet found the perfect cement.

Mr. Ricker: The chemistry department at Cornell University is using the DuPont glue for the non-inflammable film.

Mr. John G. Jones: I believe Mr. Joy understood that I meant tension at the take-up. Now, there is a big difference. The gate may cause the damage.

Mr. Joy: I don't know what the average pull is in practice, but it is one of the things that the inspector looks for carefully. The report shows that he did find many cases of improper adjustment.

I don't know whether it is proper to introduce now something which is pertinent to this question but which has come up since the investigation was made. I understand that the exchanges are experiencing difficulty with splices which do not hold. They are apparently perfectly made and are satisfactory when they leave the exchange. I don't know whether it is because they are subjected to more heat than usual in the projector, but some exchanges feel that it is due to this, because when they come back otherwise perfect, on going out, the splice is found broken apart. I believe that the effect of heat was touched on the other day when Mr. Jones stated that the Eastman Kodak Company is carrying on work relative to the temperatures of the film gate and what effect it might have on film. I think it is certainly a very important matter for everybody interested in film to think about.

Mr. Crabtree: Mr. Faulkner mentioned that the Famous Players overcome the cement trouble by using small bottles so that the cement is used up in an hour or so. I think the reason why some splices made on the same day hold while others don't may be explained by the fact that the relative humidity of the air changes. If the air is saturated, owing to the cooling produced by evaporation of the solvent, moisture is condensed on the film, and this mixed with cement on wet film prevents perfect adhesion. I think that is one reason why heating of the splicing block on some machines is an advantage.

Mr. Faulkner: Splices open very often, and the inspector or projectionist or whoever has noted this seldom takes into consideration the tint on the celluloid side of the film. We have lots of colored film which the cement will not attack sufficiently to make a proper weld. The left end is scraped, the cement is applied, and the splice is made and appears perfect, but when you scrape only the one end, and the other end which is placed on it has something on it which prevents cement from attacking it, when the splice dries out, it will open up. In a large percentage of cases open splices are due to faulty scraping or wetting or oil on the splice.

EARLY HISTORY AND GROWTH OF THE MOTION PICTURE INDUSTRY

Otto Nelson*

IN 1893, Mr. C. Francis Jenkins by his invention, the Phantoscope, gave the world something entirely new; with this machine pictures in motion were projected on a screen. He gave a number of private exhibitions, but the first public exhibition of motion pictures ever presented in America was in 1895 with Jenkins' invention at the Cotton States Exposition, Atlanta, Georgia.

The picture on the screen is the foundation of the motion picture industry, which has grown to be the fourth industry in America. Its one and a half billion-dollar investment and all its efforts are toward this end.

What is known as "moving pictures" is an optical illusion. No one ever saw movement in a picture. Your sit in a motion picture theatre and see a figure move across the screen. You do not see a moving picture, but a series of stationary pictures flashed on and off the screen. The motion picture projector is so adjusted that you see a picture. The screen is then darkened and another picture is projected; the second picture is almost like the first, and the eye retains the vision while the screen is dark. This is repeated at the rate of sixteen to twenty times a second. When the picture is gone, the eye still sees it and does not notice that the screen is totally dark half the time. This persistence of vision, when a series of views representing closely successive phases of a moving object are exhibited in rapid sequence, blends them together and gives the effect of a single picture in which the objects are moving.

The industry has developed so rapidly and motion picture photography of today is so marvelous that we seldom pause to measure the progress which has taken place in so short a time. The entire story cannot be told in the time given to this paper. The 2954 pages of the 24 published transactions of this society do not tell fully even the story of the technical development.

While the very earliest history is rather obscure, the early conception of the several devices as employed today, i. e., camera, perforator, printer, and projector, seem well authenticated in the

* National Cash Register Co., Dayton, Ohio.

exhibit to be found in our National Museum. The exhibit is made up almost wholly of the early experimental apparatus of one of our members and the founder of our society, Mr. C. Francis Jenkins. It is well worth visiting. It was acquired by the museum in 1898, and while not a complete exhibit of cine instruments, it contains every device which has been employed in the art since; i. e., cameras, perforators, developing devices, printers, splicers, and projectors; both intermittent and continuous film feed are shown in all of them as well as stereoscopic cameras and projectors, three color film and paper prints; motion pictures on card; the prismatic ring, a new contribution to optical science; and a high speed camera, which really deserves the name. As most or all of these will be shown in the motion picture demonstration to follow this paper, perhaps this is a sufficient description of this exhibit for the pictorial presentation of which I am indebted to Mr. M. W. Palmer. (See also Fig. 1)

Previous to 1889, there were numerous experiments of simulating motion by intermittent illumination of a series of related picture elements—by W. G. Horner about 1833, Coleman Sellers in 1860, Henry R. Heyl in 1870, and Edward Muybridge in 1879, E. V. Marey in 1883, and many others.

The motion picture of today is the result of the efforts of Thomas A. Edison, George Eastman, and C. Francis Jenkins. The result of Mr. Edison's experiments was the Kinetoscope. The pictures in animation were viewed through a magnifying lens in a peep hole, an electric light below the film furnishing the illumination. Mr. Eastman's contribution was the development and perfection of the flexible film base; and Mr. Jenkins was the first to project a motion picture on a screen.

Motion pictures in 1896 became the leading attraction of vaudeville and music halls, the program consisting of five or six subjects of from 40 to 80 feet in length. (Fortunately, I am able to present three of these in the film demonstration. One of these is the classic, "The May Irwin Kiss." They were made in 1895 and loaned for this occasion by Mr. George Kleine, New York). The novelty soon wore off, and for the next several years, motion pictures were used as "chasers" in the continuous vaudeville theatres.

The first movie theatre, the store show type, was opened in New Orleans in 1896. This idea was tried out in the larger cities but with indifferent success because of the lack of interesting pictures.

When Mr. Edwin S. Porter, a member of our society, conceived the idea of telling a story by motion pictures and for the Edison Company produced in 1903 the first photoplay, he brought out the kind of picture production that captured the interest of the public, and the motion picture became an essential part of the people's entertainment, which resulted in the rapid growth of the

FIG. 1. U. S. National Museum motion picture exhibit. At right examples of Muybridge's work; early Zoetropes, etc. At left machines deposited (1896) by Jenkins, including both intermittent and continuous film-feed cameras; projectors, perforators, printers; developing apparatus; stereoscopic cameras and projectors; paper films and card exhibitors.

industry. This picture entitled "The Great Train Robbery" will be presented in the film demonstration and has also been loaned by Mr. George Kleine. This production was followed by "The Moonshiners" and the comedies "The Dream of the Rarebit Fiend," "Wanted a Wife," and many other photoplays produced by the different studios.

During the next three years, thousands of "Nickelodions" were opened in store rooms in all parts of the country. The investment required to open one of these "theatres" was only a few hundred dollars. The equipment consisted of a projector, which could be bought for about two hundred dollars, a platform at one end of the room, on which was located a six by six "booth" in which was placed the moving picture machine. A muslin screen was hung at the other end of the room and two or three hundred chairs, usually rented from the local undertaker, and a wood partition across the front with a window for selling tickets completed the equipment. An "operator" was procured to grind the picture machine, and the show was ready to open.

With increasing public interest came better pictures, improved projection equipment, and the two and three hundred seat store shows were replaced by theatre buildings with seating capacities from 800 to 1200. The phonographs and tin-pan pianos were replaced by great organs and orchestras.

A new milestone was reached in 1913 with the production of feature pictures played by celebrated dramatic stars in the most successful stage plays; then came the magnificent picture playhouses in the cities. We now have the wonderful theatres of the silent drama costing millions of dollars and seating audiences of five and six thousand. Film producers now produce super-pictures, the production of which at times amounts to millions of dollars.

All branches of the industry have kept pace with this evolution, from the makers of cameras and film to the manufacturers of projection apparatus, all of them progressing with one thought—to place a perfect picture on the screen.

Perhaps the most important factor was the organization of the Society of Motion Picture Engineers in this city ten years ago, the prime purpose of which was to standardize the industry. Many of us will recall the many beautiful pictures that were ruined because cameras with different frame lines were used on the same work, one camera framed on perforations and the other between. When the old time pictures are presented in the film demonstration to follow, you will frequently see the picture out of frame; also, notice the jumpy motion of the pictures, and when the recently made titles are seen notice the steadiness. The unsteady motion is caused by the perforations of the negative film having different measurements from those of the positive, and the sprockets of the camera, the printer, and the projector may have been different. The framing line, the sprockets, and sprocket holes were the first things standardized, and hundreds of other things have been accomplished by the Society in its effort to place a better picture on the screen.

The motion picture projector and equipment in use until 1904 was of very simple construction, consisting of an optical system, a mechanism providing an intermittent movement, an upper or feed sprocket and a shuttle. It was operated by a crank turned by hand. There was no take up device; the film while being projected was run loosely into a bag, a box, a barrel, or a basket.

The illumination was provided by an electric arc with half-inch upper and lower carbons using twenty-five to thirty amperes for both direct and alternating currents. The voltage was controlled by a rheostat of high resistance wire. The lamp house, when one was provided, was a small affair about six inches wide, a foot long, and a foot high. In places where electric current was not available, calcium or lime light provided the light source.

The opening of thousands of store shows during the years 1904 to 1908 created a demand that started the development of the present high-grade equipment. The motion picture engineer has kept pace with the growth of the industry. The building of larger and more beautiful theatres that started in 1914 included better projection equipment.

Until 1904 or 1905 the one projector in the six by six booth was handled by a picture machine operator or crank turner who at the end of each reel projected a lantern slide which read "Just a moment please while the operator changes reels." This has changed with the development of the industry. We now have well constructed properly ventilated, commodious projection rooms that contain high-grade equipment costing thousands of dollars, built with precision, some parts to a measurement of a ten thousandth of an inch; the current is regulated by motor generators and the machinery electrically driven.

The old time operator has developed into the projectionist, whose profession has become a highly specialized one requiring careful work and expert knowledge in mechanics, electricity, optics, screen surfaces, and many other things. He must know how to apply this knowledge to the profession of projection. As the picture on the screen depends on the final act of projection, the projectionist is as important as any person in the industry. All the work of the highly paid directors, stars, scenic artists, and expert camera men who produce wonderful photographic results mean nothing unless it is perfectly projected. There are some projectionists who have not kept up with the times, but many are waking up and procuring the expert knowledge necessary to keep them at the top notch of their profession.

A recent advancement in the industry is "the Theatre Managers Training School," which has been established recently by a large theatre circuit organization. Among other things, the students have been educated in the correct presentation of the picture on the screen. When all of the managers have been properly educated, we will have no more glare spots in motion picture theatres, especially the reflection of light on the sheet music in the orchestra, which annoys the audience by causing eye strain and by interfering with the proper view of the picture. The fine productions will not be outraged by the manager compelling the projectionist to overspeed the projector in order to keep within a given schedule. This still exists in some of our best theatres, the entire picture program being projected as fast as a hundred feet of film per minute.

The non-theatrical branch of the industry has made wonderful progress since the first industrial motion picture was made in 1902. Non-theatrical films are now used for numerous purposes by industry and by national, state and municipal governments; by Boards of Health and all kinds of organizations for the promotion of membership and for building funds and conducting money raising campaigns. The use of motion pictures in churches and educational films in the class-rooms of our schools is rapidly developing. The manufacturers of semi-portable and portable projectors are making equipment to meet every demand. And, finally, the recent development of cameras and projectors for home use has opened up a new field that has unlimited possibilities.

THE FIRST USE OF STEREOSCOPIC PICTURES IN MOTION PICTURE THEATRES

J. F. Leventhal

IN the field of stereoscopic reproduction in motion pictures there seems to be very little if any hope of development. The obstacles seem insurmountable. Briefly stated, the difficulty lies in the fact that we see things stereoscopically because we have two eyes. Each eye sees a different view, and it is the fusing of these two different views into one view that gives us the effect of depth. Now, in order to get the effect of depth in motion pictures, it is necessary to simultaneously project two different views, one view of which is visible only to the right eye, and the other to the left eye. It is obvious that with the naked eyes, each eye will see both views. There does not seem to be any way to show two views at once and have the eyes receive them selectively if we look without the aid of special apparatus. It has long been known, however, that stereoscopic motion pictures could be shown if each observer was supplied with a viewing instrument which made it possible for the right eye to see the right eye picture, and the left eye the left.

There are several systems of stereoscopy that may be employed and I will try to explain two of the more practical ones.

The first system employs an instrument called the "Teleview." This consists of a revolving blade which alternately cuts off the view of the right eye and left eye. When the left eye view is cut off for a tiny fraction of a second, the right eye sees the right eye picture, which is visible on the screen for just that length of time. When the right eye view is cut off, the left eye sees the left eye picture which has replaced the right eye picture. Every member of the audience is supplied with one of these machines. The blades must all synchronize perfectly, so that every one in the audience is looking with the same eye at the same time. It is in the perfection of the electrical synchronization that the inventors of this system are to be complimented. The resulting effect is excellent, as was demonstrated at the Selwyn Theatre in New York, but there are difficulties, as you may imagine, on the practical side.

A simpler if less efficient system is the Anaglyph method. This dates back to the nineteenth century, when it was applied to slides. A number of attempts have been made to employ this system. Briefly, it consists in superimposing the left eye and right eye pictures on the screen. One picture is colored red and the other green. The observer looks through a pair of spectacles containing a red filter and a green filter. The eye looking through the green filter sees only the red image, and the other eye, looking through the red filter, sees only the green image. In this way, by proper arrangement of the colors, the right eye is enabled to see the right eye picture only, and the left eye the left eye picture only.

The introduction of pictures of this type was beset with many difficulties, one of which was the handling of the spectacles in conjunction with the film. The physical handling and selling of motion pictures is a rock-ribbed affair and hard to dent. Here was a type of film that meant a departure from routine in every department, from the home office of the national distributor down to the porters that clean the theatre. It was obvious at the beginning that if the exhibitors were to accept this kind of picture, it would be necessary to emphasize the spectacular side and make scenes that would startle the audience, rather than views of streets and scenery.

Let us follow through the various departments of the industry and see how a departure such as this affects the machinery:

First, we have the home office of the distributor. It must invest thousands of dollars in spectacles to supply its exchanges. On the first picture alone, it was necessary for the distributor to make an initial investment of $40,000 in spectacles alone, to say nothing of color prints costing about eight times as much as black and white prints. This is not a large sum as motion picture sums go, but it is enormous when considered as an expenditure necessary to put over a film costing only seven or eight thousand dollars.

Next, we come to the exchange. It must stock up with spectacles and introduce some sort of system to insure delivery on time to exhibitors. The salesmen find added selling resistance because they must sell not only the film but the spectacles.

The exhibitor is usually averse to spending money on things that are given away without bringing him an additional return at the box office. Most of his money is spent on his feature, and that, of course, is his drawing card.

The house manager feels that the distribution of the spectacles slows up his show, though the system used now is to give them out at the door.

And last but not least, there is the porter. The spectacles cannot be inhaled by his vacuum cleaner and must be picked up by means of physical exertion. This annoys a great many porters.

There is one branch of the motion picture family more important than any of these, the audience. If they are pleased with a certain kind of picture, they will eventually get it. They have been pleased with the pictures made so far except in one or two instances. This was when the exhibitor neglected to distribute spectacles.

Some improvements being made in this system will eliminate most of the trouble, and then we may hope to see stereoscopic pictures shown very often, but they will probably never be shown without viewing apparatus of some kind. Therefore, they can never occupy more than a few minutes on a program.

(Demonstration)

The film exhibited was a modification of the usual anaglyph stereoscopic film, the red image depicting a scene entirely different from that given by the green image. By looking at the screen through the red filter of the spectacles, one scene was revealed and the other scene was seen by looking through the green filter. The scenes were so chosen as to supply either a happy or sad ending to a picture by looking through either the red or green filters.

SYPHONS AND MEASURING DEVICES FOR PHOTOGRAPHIC SOLUTIONS*

K. Hickman

THE DEVELOPING of 35 mm. positive film, and of 16 mm. reversal film is being accomplished with continuous processing machinery. That the tendency to employ mechanical means is increasing is shown by the patent literature in which a recent application describes a continuous apparatus for handling roll film.

The problem of mixing and evenly supplying solutions containing perhaps hundreds of pounds of reagents is one which continues to exercise the chemical engineer of the film laboratory. In this paper are gathered together a number of measuring syphons and devices which have been tried out practically by the author recently and during the past few years. Although they by no means cover the whole field, they do attempt to deal comprehensively with a section comprising devices having no mechanical moving parts.

There are perhaps three essential requirements in handling a photographic solution.

1. The temperature must be kept constant.

2. The amount delivered per unit time or unit footage of film must be controllable.

3. If necessary, solutions such as the A and B portions of developer must be kept separate and mixed only when required.

A skilled worker can perform the mixing, but the addition in batches every few minutes or continuously by so-called constant delivery jets of the various solutions is an irksome job and one which costs money in labor.

Temperature control is beyond the scope of this paper; to, perform the other operations automatically we require:

A. A method of delivering liquid in quantity proportional to the film fed into the machine, even though this be variable in rate or actually intermittent or;

B. A method of delivering liquid at a constant rate.

* Communication No. 274 from the Research Laboratory of the Eastman Kodak Co.

A. The Solution is Controlled by Film Footage

If the addition of liquid through a calibrated orifice is objectionable for reasons enumerated under B, addition through an orifice controlled in aperture by film speed is quite impracticable. It is necessary, therefore, to measure out the solution in a series of unit quantities so small and so frequently delivered that the great bulk of liquid in the machine is renewed without noticeable discontinuity.

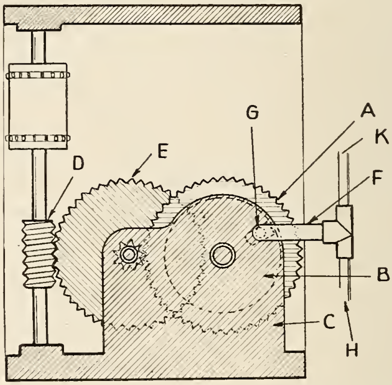


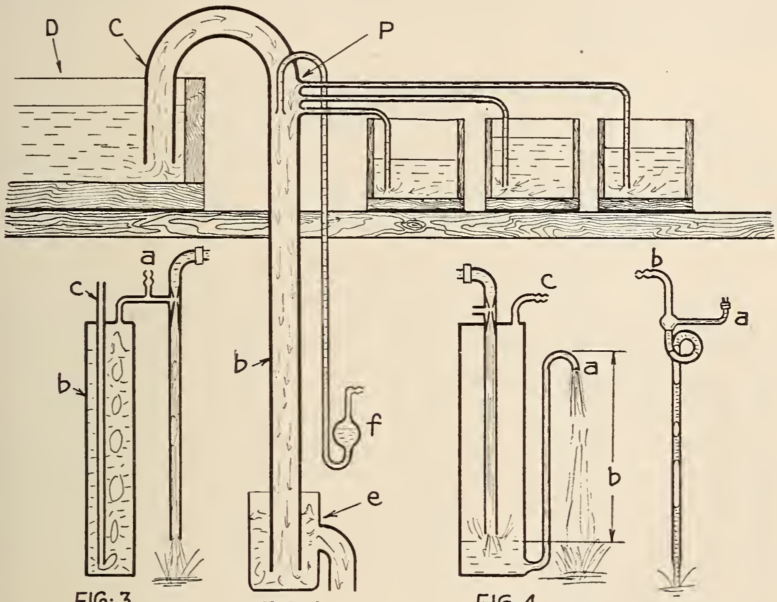
Fig. 1. Timing device actuated by sprocket drive for controlling the addition of solution from the measuring apparatus of Figures 6, 7, 8, and 9.

This has been accomplished by pneumatic means. At some point on the machine, and driven by a master sprocket wheel or even by the film itself, is located the release valve device shown in Fig. 1. Here the valve wheel *A*, having upon its upper face a raised portion bearing on the support *C*, is rotated by the worm and clock wheels *D*, *E*. Through the bearing wall *C* a tube *F* has its far end periodically uncovered by the slotted hole *G* in *A*, at a rate dependent on the ratio of gearing to film travel. A convenient rate is furnished by one uncovering to every twenty or a hundred or even a thousand feet of film. The branch tubes *H* and *K* pass on to the pump and measuring units.

For actuation either pressure or vacuum may be employed, and so slender are the requirements for even large bulks of liquid that injector pumps fitted to the water supply of the washing tanks will do all that is needed. With the pump must be incorporated some constant pressure device so that the liquid shall not be carried beyond the measuring bulbs into the service pipe lines.

Vacuum Constant Level Pumps

A water injector known in chemical laboratories as a "filter pump" may be connected in parallel with the service line *A* (Fig. 3)



FIGS. 3, 4, 5 AND 6. Figs. 3, 4, and 5 illustrate well known methods for obtaining pressure or partial vacuum from water jets. Figure 6 is an intermittent measuring and mixing syphon.

and with a tall narrow water tank *B* about a foot higher than the maximum height to which liquids will be drawn on the processing machine. A tube *C* carries air down below the level of the water and releases the vacuum whenever this tends to increase above the correct amount.

A fool-proof device of limited capacity is the simple "kinkle tube" of Fig. 5. If a glass or smooth metal tube of not more than ⅜″ internal diameter be bent in the form shown and a side tube be introduced above the kinkle, admission of a limited quantity of water down the tube *A* will cause air to be sucked into the tube *B*.

The reason lies in the tendency of water to accelerate to a maximum speed dependent on the height of fall and the skin friction of the tube. If less water is supplied than required to give the maximum speed, air is sucked in until the weight of the mixed column of air bubbles and water corresponds to the actual acceleration obtained. From bend to exit this tube should also be about a foot longer than the required lift. A bundle of half a dozen will take care of a large processing machine.

Constant Level Pressure Pump

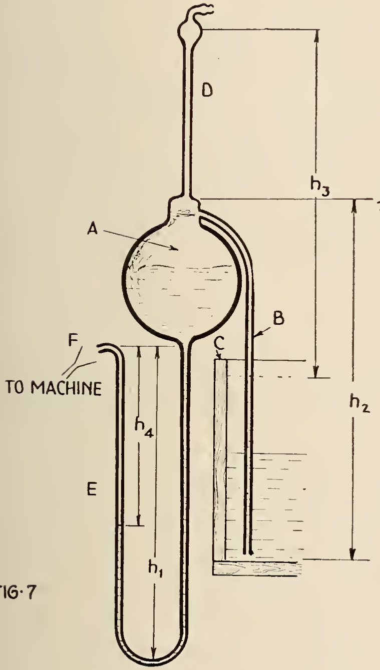
The injector of Fig. 3 may be fastened directly to the tall tank and the water with unwonted excess of injected air allowed to escape from the side tube A in Fig. 4. The pressure delivered at C will be determined approximately by the height B.

The Vacuum Measuring Unit

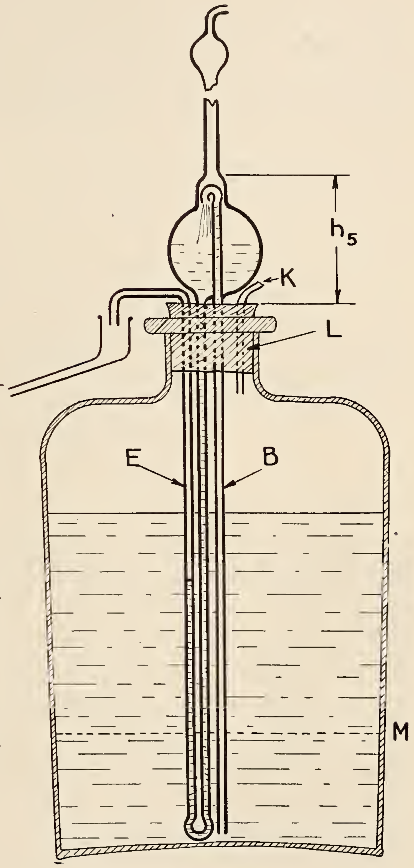
A container A, Fig. 7, holding the amount required for delivery at each impulse has a filling tube B entering sideways at an expansion of the neck and dropping to the bottom of the supply tank C. The delivery tube E reaches from A to below the supply tank and up again to a funnel F on a level with the bottom of A, feeding the machine. The suction or actuating tube D forms an extension of the expanded neck. The dimensions are important and are such that the distances h_1 and h_3 are each greater than h_2, the latter being the greatest distance the feed liquid must ever be sucked, i. e., when the tank is nearly empty.

The action is self-evident. When suction is applied at D, liquid rises in B and tumbles into A. Air is unable to enter at E because of the water pressure corresponding to the column h_1. The action ceases when the bulb is full and solution has risen to a height in D such that the difference in level between that and the feed tank is equal to the constant level column in the suction pump (Figs. 3 or 5) When the vacuum is released, the contents of tube B drop back into C and of the bulb A, into the funnel. The amount delivered is constant except for variations in height h_4 determined during filling by the state of exhaustion of tank C. As the volume of E need not be more than a fiftieth of A, the inaccuracy seldom exceeds one per cent.

The arrangement may be applied to dispense liquids from a large bottle or carboy, as in Fig. 8. The filling tube B and discharge tube *E* with an air vent *K* all pierce the cork *L*. As the bottom of *E* should be situated below *B* by an amount corresponding to h_5,



FIG·7



FIG· 8

FIG. 7. Vacuum operated measuring bulb.

FIG. 8. Illustrates a practical application of the vacuum bulb of Fig. 7.

a condition manifestly impossible, the bottle cannot be emptied beyond the level *M*. If the solution has keeping power, this is of little consequence, each new day's batch being tipped in on top of the old. By letting *E* drop down outside the bottle, however, complete emptying can be secured; this has been found cumbersome in practice.

Great simplicity combined with accuracy in delivery can be secured by operating the measuring unit with a constant level device.

In Fig. 9 are pictured three well known ways of maintaining a constant level. To save illustration space, they are shown operating on one tank and with their relative dimensions falsified. The float valve *A* is life size, but the ball *B* and the bottle *C* are from one-third to one-tenth their true linear dimensions. *A* and *C*

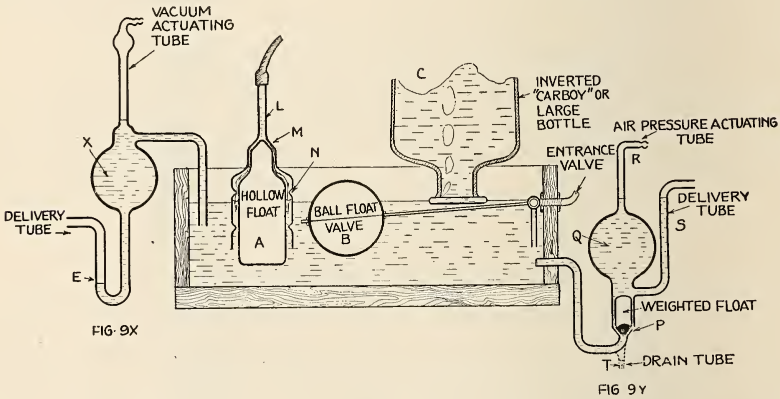


FIG. 9. Figures 9, a, b, c, are constant level devices, while 9x and y show the application to short limbed vacuum and pressure operated measuring bulbs.

will deal with the most corrosive or oxidizable solutions, while *B* must be reserved for water, sodium carbonate, etc.

A. An inverted glass bell vessel terminates in a truncated supply tube *L*. Into the neck *M* the conical tip of a hollow float presses only when buoyed up with sufficient liquid in the trough. Indents *N* in the wall of the bell vessel prevent the float's sticking to the sides by surface tension. The occasional failure of such valves owing to dirt on the seating is minimized in effect owing to the ease of cleaning in this simple application.

Methods *B* and *C* need no description.

A small trough kept constantly filled by a large distant supply tank will deliver liquid to the device Fig. 9 X, corresponding to Figs. 7 and 8. Here the limbs may be short and wide giving rapid delivery, because the liquid always sinks to the same height in the discharge tube *E* on filling. There is accurate delivery because there is no stem effect. The exit of the delivery tube *E* should be above the level in the supply tank and not as shown in sketch.

Positive Pressure Delivery

Pressures greater than atmospheric, such as from the pump, Fig. 4, may be used to actuate the device *Y*, Fig. 9. Here solution is allowed to fall naturally past the weighted valve into the bulb *Q* situated below the high water level. Application of pressure to *R* drives the contents of *Q* out of *S* up as tall a tube as desired to reach the destination. The air supply must be sufficiently vigorous to create an excess pressure in the tube even when all liquid has gone; otherwise, solution will creep past *P* and be blown up *S* after the manner of an air lift pump. This is the only drawback to an otherwise very positive method of delivery. The valve *P* has not been known to stick, but in such an event the drainage of dirt from a side tube *T* is a simple matter. This type of measuring unit may be applied very successfully to the emptying of large bottles with tubulures at the base. It is only necessary that the tubes *R* and *S* should be prolonged above high water level when the bottle is full.

Vacuum Operated Mixing Syphon

A useful application of the vacuum control consists in the syphon device pictured in Fig. 6. Consider the bent tube comprising a short upper limb *C* and a long lower limb *B* having the open ends located in a tank *D* and a water seal *e* respectively. When syphon action is initiated by withdrawing air through *F*, liquid passes from the tank through the syphon in the well known manner. Except a small fraction lost in friction, the whole of the potential energy is converted into kinetic energy in accelerating the water from zero velocity in the tank to that with which it rushes down the pipe. As a result, even while flushing with the flow quite unrestricted the suction developed at the point *P* is practically as great as it would be with the shorter limb closed and the syphon full of water. This property may be utilized to incorporate small quantities of liquid with a large main bulk with extreme accuracy and thorough mixing. Developing agent and restrainer (pyro and bromide) may be incorporated with a stock solution of carbonate and sulphite. Acid hardener or ferricyanide may be added to hypo, or small quantities of dye solution may be diluted without mess for tinting positive film. All that is necessary is that the requisite number of small tubes dipping into miniature tanks shall communicate with a large syphon near the top of the bend. An example will describe the utility of the arrangement. Suppose that a hundred gallons of hypo have been prepared in the main tank and it is required to add half a gallon of liquid hardener and then deliver the mixture to the service processing lines: With a two-inch syphon

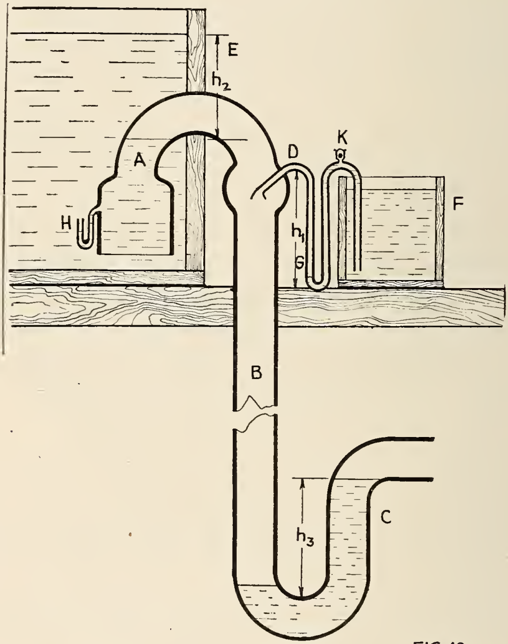


Fig. 10. Self starting flushing and measuring syphon controlled by increase of level in supply tank.

tube running to the floor below, discharge will be complete in about a minute. The half gallon of liquid hardener would be sucked in uniformly throughout the bulk through about a quarter-inch diameter side tube. This is so wide that it suffers from none of the disadvantages of the minute calibrated jet which would be required if delivery were spread over an hour or two. Fig. 6 shows the arrangement applied to three tanks.

The most recent application of this method of mixing would be its combination with a submerged bend syphon of Moras' U. S. Patent.* Fig. 10 shows the essential layout comprising the double

* U. S. P. 1,421,531, July 4, 1922.

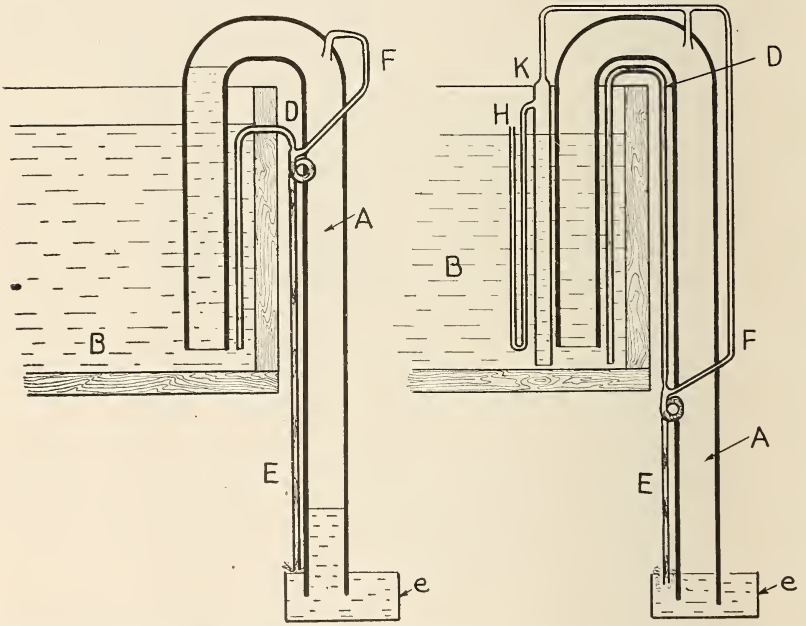
knee syphon *A*, *B*, *C* with actuating tube *D*, also double kneed. Let *A*, *B* pierce the wall of the main tank *E* and *D* straddle the wall of the subsidiary tank *F*. Suppose that *F* and the lower limb *G* of the actuating tube *D* are full of liquid. Now fill the sump *C* of the main syphon and commence filling *E*. After water has closed *A* and the break tube *H*, air imprisoned in *A* will resist the rise of water in the limb until, when the limb is full, the levels in the three bends *A*, *C*, and *G* will be shown as in the picture. If the height in h_1 is less than h_2 and h_3, increasing the level in *E* will suddenly drive the water out of *G* into *F* and a little past the ball valve *K*. Air will follow the water until the large syphon is filled with liquid from the tank *E* and the flushing action commences. The excess pressure in the tube *D* now turns to vacuum, causing the ball to tighten in its seating and a quantity of the contents of *F* to pass into the liquid stream. When the limb is empty, air enters at *H*, breaks the syphon column in *B*, *C*, and *D*, leaving *D*, *G*, and *C* primed for the next filling. Using the example of hypo and the acid hardener, enough hardener would be compounded in the small tank for a week's use (possibly held in an inverted bottle to maintain a constant level). The day's portion of hypo would be mixed in *E*, three-quarters full of water, and when dissolved the hose turned on. As soon as the right dilution had been reached, and hence the right level, the tank would flush, sucking in hardener and at the same time warning the operator to turn off his hose.

One of the problems that besets the hydraulic engineer is the initiation of a very large syphon stream with a very small amount of water. It is the problem which makes the design of a self-flushing proprietary cistern so complicated. It is required that a tank should fill very slowly and empty rapidly. The overflowing of the slow filling stream down the large emptying syphon is not sufficient to start a flush, but must be made to do so.

The object can be achieved in two ways without the use of mechanical moving parts.

(*a*) *The wall of the vessel may be pierced*: A syphon tube *A*, Fig. 11, connects a tank *B* with a liquid seal *E*. Through the wall of the tank at the level at which flushing is desired to commence the small syphon tube, *D* emerges and connects with a kinkle fall tube *E* and a syphon exhaustion limb *F*. When the liquid rises in *B* sufficiently to flow down *D*, air becomes sucked out of *A* and syphon action started. When the tank is empty, air enters at the inner end of *D* or *A* and breaks the column, leaving the cycle to be repeated a second time.

(*b*) *The Syphon Straddles the Wall of the Vessel* and can be actuated either by incoming or outgoing water. In this event, the syphon *A* is being constantly evacuated either by means of the



Figs. 11 and 12. Fig. 11 shows an intermittent flushing syphon of which the level tube pierces the wall. In Fig. 12, the same device is adapted to straddle the wall of the vessel.

fall tube *E* or by a venturi pump on the incoming stream, as in Fig. 12. The exhaustion tube *F* is connected with a level control tube *H* and a compensator *K*. The top and bottom of *H* correspond with the upper and lower levels to be maintained in the tank. In operation, continuous evacuation of *A* tends to initiate the syphon action but is unable to do so because air can enter by *H*. When, however, the level rises and liquid tumbles down *H* sealing the system, syphoning starts in the usual manner. If *H* were connected directly to *F* its contents would be subject to suction corresponding to the whole fall down the long limb of the syphon, as explained previously. By placing the wide tube *K* in parallel, water is sucked into the top of *A*, but the acceleration in the wider part of *K* where *H* joins is so small that the suction is sufficient only to hold the water in the outer limb of *H* just below the level in the tank at any moment. When the level reaches near or below the bend, *H* is cleared of water by the increasing suction, air enters the syphon, the column is broken, and the cycle repeats.

It will be seen that where the outgoing stream is relied on for initiation either it must pierce the wall at the correct level or it must be shaped so that the branch tube *F* and the kinkle *E* are below the lowest level ever obtaining in the tank, so that the flow in the small tube is not broken when the tank is empty.

In conclusion, it should be stated that the descriptions and diagrams are intended to show methods of measuring and syphoning without limiting their scope and by way of example only. Thus, the mixing syphon of Fig. 6 may be operated intermittently by the control valve of Fig. 1. The liquids in tank *E*, Fig. 6 or Fig. 9, may be measured in by the unit device of Fig. 7, so that the renewal of, say, hypo as a complete flush throughout the system may be initiated once a day or so, according to the quantity of film processed.

B. *Calibrated Orifices*

It is not intended to deal with any more than the drawbacks of such devices. Where a constant head of liquid is available, together with wide pipe lines and adequate filtering, a small jet may be employed to deliver liquid at a constant rate to a processing machine. Apart from the necessity of turning off the jet when the machine stops, a small particle of dirt or, worse still, a deposit separating from the solution, or an enlargement caused by corrosion will alter the accuracy of the setting. These calibrated jets are mentioned merely to show the desirability of using a positive and unit measuring system such as detailed in the body of the paper.

A TWELVE-YEAR TRIAL OF EDUCATIONAL FILMS

Fred W. Perkins*

THE EXPERIENCES of the United States Department of Agriculture in the production, distribution, and exhibition of educational motion pictures have been of such magnitude that they may offer a measuring stick by which the future development of films of this type may be judged.

The Department has been working with films for fourteen years. It has produced more than 300 subjects, of which 230 are now in active circulation, and from its laboratories in Washington is distributing regularly more than 2,000 reels, while an approximately equal number of reels of the same subjects is being distributed by states agricultural colleges and other institutions that have purchased them. The Department maintains its own production staff, and each year adds from 25 to 30 new subjects to its collection of films.

A small beginning has grown to an office and laboratory employing twenty people. The desire of various branches of the Department for new films and the possible uses for them are great enough to provide work for a considerably larger force. But a reasonable rate of growth, rather than a quick expansion, has been the rule in this activity. Other policies that have been followed are to avoid competition in any way with the commercial producers of motion pictures, either theatrical or educational; to make every film have a direct relation to the work of the Department; to give every film a definite educational purpose; to make all films easily understandable by the layman of average intelligence; to inject into them as much human interest as is compatible with their subject matter and educational purposes; and to make the films applicable and valuable over the widest possible territory and to the greatest possible number of classes of people. Another aim is to vary the subjects and eventually to cover as many as possible of the hundreds of important lines of work in the Department. Already, a general summary of the major subjects in films includes the following:

Beef cattle, dairy cattle, dairy products, diseases of cattle, parasites of cattle, horses, sheep husbandry, swine husbandry,

* Director, Motion Picture Division, U. S. Department of Agriculture.

diseases and parasites of swine, poultry production, poultry pests, wild game and bird protection, destructive rodents, cereal crop production, cereal crop handling, cereal insects and diseases, cotton production, cotton insect control, fruit production, fruit insects and diseases, truck crop production, plant diseases, home gardening, miscellaneous crops, farm engineering, types of road construction, food inspection work, other public inspection services, forest fire prevention, forest insects and pests and tree diseases, lumbering, scenic and recreational resources of the national forests in the East and West, reforestation, miscellaneous forest uses, bees and other insects, marketing of farm products, cooperative marketing, rural organization, agricultural extension work, boys' and girls' club work, rural sociology, weather forecasting.

The basis on which this work is done goes back to the beginning of the world's history. The annals of humankind demonstrate that a strong, independent, resourceful, and prosperous farming class always has been essential to the continued existence of a nation. In the United States the often-heard statement, "Farming is the nation's backbone," is much more than an empty phrase. Farming in the United States is an eighty-billion dollar industry, and any one of our other great industries, and in fact, several of them together, bulk punily beside it. Depression in farming is inevitably followed by depression in general business. That is why the corn crop, the wheat crop, and the cotton crop draw continuous and close attention in our great financial centers. The importance of building a strong agriculture in the United States was early recognized. George Washington, in his last annual address to Congress, said, "It will not be doubted that, with reference either to individual or national welfare, agriculture is of primary importance. In proportion, as nations advance in population and other circumstances of maturity, this truth becomes more apparent and renders the cultivation of the soil more and more an object of patronage." Abraham Lincoln, in an address to Wisconsin farmers in 1859, said, "Farmers, being the most numerous class, it follows that their interest is the largest interest." Theodore Roosevelt wrote, "We are founded as a nation of farmers and in spite of the growth of our industrial life it still remains true that our whole system rests upon the farm; that the welfare of the whole community depends upon the welfare of the farmer; the strengthening of country life is the strengthening of the nation."

In 1839, in a small division of the Patent Office, a beginning toward the work of encouraging agriculture was made in distribution of seeds and plants from abroad. In 1862, the Department of Agriculture was established and in 1889 was raised to the first rank in the executive branch of the Government. The Department now embraces twelve large bureaus and eight other administrative units working not only in every phase of agriculture but in the closely-related fields of forestry, road building, and home economics, and also enforcing a large number of regulatory laws, such as the so-called "pure food," the meat inspection law, and the plant and animal quarantine laws. The organic act establishing the Department provided, as a major duty, that it should "acquire and diffuse among the people of the United States useful information on subjects connected with agriculture in the most general and comprehensive sense of that word," and thus its function is not only research and regulation but includes also carrying to the people the results of its scientific investigation. In this dissemination every modern instrument has been employed. and among these an important one is now the motion picture.

The field for our films includes, first of all, a widespread organization known as the Agricultural Extension Service, made up of county agricultural agents, home demonstration agents, boys' and girls' club agents, and subject matter specialists employed cooperatively by the state and federal governments and working in every agricultural county in the Union. There are nearly 4000 of these agents. A large proportion of them are now regular users of films, many others use films less regularly, and all the others are prospective users. Then, as other active users, we have the field organizations of various bureaus, such as the forest rangers of the Forest Service and the animal disease control forces of the Bureau of Animal Industry. We give preference to film requests from these workers, but we have been glad to send available pictures to thousands of other applicants, including farm bureaus, granges, schools and colleges of every grade and kind, livestock organizations, women's clubs, garden clubs, sportsmen's associations, churches, Boy Scout troops. business men's organizations, museums, theatres, fairs and other expositions, conventions, community organizations, hospitals and penitentiaries, hotels and summer resorts, and traveling lecturers and railroad development trains.

Our reports show that between nine and ten million people see our films each year. The actually reported number of people before whom they are shown shows an encouraging and steady growth, and another definite indication of this increase is given by the number of film shipments from our laboratory to all classes of users and for use during periods ranging from a few days to six months. In the fiscal year 1922, the number of such shipments was 2,066; in 1923, it was 2,715; in 1924, it was 3,199; and in 1925, it was 4,260. Thus, in three years, the number of shipments has more than doubled. The films in any one of these shipments may be exhibited before ten or a hundred thousand people or even more before they are returned to our laboratory. Sales of prints, especially to state agricultural colleges, also show a steady growth. We feel no doubt that with the continued acquisition of projecting machines by agricultural extension and farming organizations, as well as by other classes of non-theatrical film users, the field for our films will continue to widen.

As to the results of this work up to date we believe there is no official of the Department of Agriculture acquainted with what has been done who is not thoroughly impressed by the efficiency of motion picture films in advancing the work in which the Department is engaged. There are now exceedingly few important extension or educational projects in the Department that have not called for the making of a motion picture for use in their campaigns. It is becoming increasingly the rule to regard a motion picture as one of the essential field guns in any educational campaign. We do not believe, however, that films will displace the use of other methods of disseminating information. We think that lantern slides, for instance, have their own particular use, and that just as it is impossible for the slide to perform the function of the motion picture, so it is not possible for the motion picture to take over entirely and efficiently the function of the slide. It appears to us that the big use of the motion picture is to "break the ice" and create favorable sentiment for a particular movement. For instance, we have a film on animal tuberculosis that has been used in every section of the United States to give the initial impetus to community movements for the eradication of this disease. The film has been almost uniformly successful in "opening the door" for the campaign, but the promoters of the movement are wise enough to follow the film with several other types of educational material. We are satisfied if the film performs well its first and prime duty but are often encouraged by reports such as this (from a county agricultural agent in Iowa):

"Your film,'Out of the Shadows,' gave the initial impetus to the anti-tuberculosis campaign and also carried it through to completion, with the result that this county is now free of the disease."

We regard the county agents and other extension and field men of the Department as "the men on the firing line" and think that their contact with the public places them in the best position to evaluate the educational tools, such as films, which are supplied to help them in their work. With the thought that expressions from these men constitute valuable testimony on what can be done with films, the following are appended:

From annual report of the county agricultural agent of Lyon County, Kansas:

> This was the first farm bureau in Kansas to purchase its own complete motion picture outfit. Motion pictures have been exhibited at 52 meetings to a total attendance of 6,608 people.
>
> The advantages from using motion pictures in conducting educational extension work might be summarized as follows: Holds attention of all audiences; increases attendance at meetings; brings out more forcefully and more intelligently the points desired; 'seeing is believing' and more people put into practice things they can see and understand than those they hear about; a balanced and varied program can be put on to interest all in attendance; the agricultural agent can carry more specialized work to the farmers and be independent of outside specialized assistance; and the cost of maintaining the farm bureau, figured on the basis of work accomplished and people reached, is materially reduced.
>
> The disadvantages from using motion pictures are that the county agent is forced to do more night work, work considerably longer hours, take on the added responsibility of pleasing more people and never disappointing them, take on the worry and grievance that is bound to come from the delicate mechanism of motion picture machines and apparatus, travel all kinds of roads in all kinds of winter weather, and be contented with using the kinds of films that can be secured.

The county agent at Duncan, Arizona: "The showing of moving pictures has done more to arouse interest in this county than any other one thing that I have tried."

An extension specialist in the Illinois College of Agriculture: "Motion pictures are the most satisfactory means of bringing educational facts before people in country communities that we have found so far. We find this is true especially in those towns where there is no movie theatre."

The county agent at Preston, Idaho: "In carrying out the Extension Division program I have found this one of the best methods of putting across any piece of work that I have ever tried."

The county agent at Ellsworth, Wisconsin: "A good many things can be put across by a motion picture that cannot be done otherwise."

The county agent at Grand Haven, Michigan: "Moving pictures certainly pack the hall and give the extension speaker a method of demonstrating to a larger attendance, making it possible to reach at least 100 per cent more people than could be reached without the aid of pictures."

The county agent in Allen county, Kansas: "The agricultural agent contemplating the purchase of a motion picture projecting machine may expect late hours, some worry, considerable expense for upkeep, but he can reach three times the number of people that can be reached in any other way."

This is not to mean that the county agents are a solid and enthusiastic unit in favor of the motion picture. Many of them would not make such statements as those quoted. For instance, from an inquiry four years ago, we received 982 replies. Of these, 820 agents expressed themselves as in favor of using motion pictures in their work; 149 were non-committal; and 13 did not favor them at all. Approximately the same proportion of sentiment was revealed in a more recent inquiry.

Most of the county agents using films exhibit them by means of portable projectors, often with electric current supplied by a portable generator or a set of automobile batteries. Two branches of the Department, and several agricultural colleges, are operating motor trucks equipped to carry motion pictures into isolated regions which never before have had the opportunity to become acquainted with the "silver screen." An experience—not an extraordinary one—of the operator of one of these trucks is told in the following press story given out by the Department:

In the field of the celluloid drama it is not only the movie actors or the camera men who run risks, but at times even the projectionists who show the pictures in public. In a report received by the United States Department of Agriculture from Ed. F. Pickering, agent in tick eradication, the thrills of moviedom come from many sources. Mr. Pickering is in charge of a motion-picture truck which carries the message of the benefits of eradicating cattle ticks to regions where, for various reasons, the work is misunderstood and sometimes vigorously opposed.

"Mollie of Pine Grove Bat" is the title of a three-reel feature recently released by the Department which shows how plucky people in one community eradicated ticks in spite of serious obstacles and opposition by a lawless element. This picture was recently shown in a community known for several years to be hostile to the eradication of cattle ticks, and was shown under dire threats that any attempt of preliminary tick-eradication work by means of motion pictures would be futile. Threats had been made to blow up the "damn tick wagon". The wagon arrived, nevertheless, and the show began before an audience that included a crowd of bullies and the local "bad man". With the unweaving of the story, however, which showed clearly that only selfishness and prejudice oppose the useful work of tick eradication, opposition melted. The leader, instead of whipping Mr. Pickering as he said he would do, shook hands with him before he left.

In other districts where opposition has been so strong as to make the efforts of tick eradication hazardous, the power of the silent drama has made friends of former opponents and is preparing the way for better livestock and more prosperous citizens.

Our conclusion from the foregoing is that the experiences of the Department of Agriculture prove that the expense and difficulties involved in the use of educational films are amply counterbalanced by the effectiveness of this medium of expression; and we further believe that the field for educational films in general, while probably not so extensive as has been forecast by some distinguished commentators, is yet largely undeveloped and contains possibilities of which the realization would equal or even exceed the uses, great as they are, of the entertainment film.

The Society of Motion Picture Engineers can aid educational films by working toward simpler, less expensive, and more efficient portable projectors and portable electric generators; by increasing the durability of the slow-burning or non-inflammable film stock; and by encouraging the fire prevention authorities to take note more generally of the practically negligible hazard involved when slow-burning films are used in a portable projector of the modern type.

THE USE OF MOTION PICTURES FOR GOVERNMENTAL PURPOSES

Raymond S. Peck*

APPROXIMATELY thirty years ago the birth of the motion picture may be said to have occurred. Newspapers at that time describing the invention, which was exhibited in the Marlborough Hall of the Polytechnic in Regent Street, London, spoke of it as "A contrivance by which a real scene of life and movement may be produced before an audience in a life-size picture."

We have journeyed far in the comparatively brief span of thirty years. Today the modern motion picture film has interwoven itself into the warp and woof of our world civilization to a degree that is little short of marvellous. This world-wide acceptance of the motion picture by the various nationalities scattered over the "seven seas" has been the means of developing a tremendous industry and fostering what may be termed a universal language, the "language of pictures."

The modern motion picture film is a medium that knows no frontiers. As a writer recently said, "Language varies, manners vary, money varies, even railway gauges vary, but the universal unit in the world today is that slender ribbon of celluloid which can carry hokus-pokus, growing pains and dreams."

Because of the world-wide acceptance of motion pictures, the film industry is today charged with a great responsibility. Within its grasp is a medium of human expression and power undreamed of a few years ago. The invention of printing and the subsequent advent of the newspaper in 1632 was an epoch in world history. In the light of present-day developments, the introduction of the first flickering motion picture in 1896 marked another epoch perhaps as significant to humanity as that of the invention of printing.

I need not emphasize from a purely commercial angle, the marvellous Alladdin-like growth of the motion picture; nor will I dwell on the great responsibility vested in the film industry because of the power of the film. I do, however, want to call attention to the tremendous national and international potentialities that are inherent

* Canadian Government Motion Picture Bureau, Department of Trade and Commerce, Ottawa, Canada.

in the narrow ribbon of celluloid and also to the fact that the governments of the world are more and more concerning themselves with the use of motion pictures. One of the significant developments of the motion picture industry today is this interest which is being manifested by leading governments in the medium of the film. It has been said throughout the British Empire that "Trade Follows the Flag." Today a new slogan has been coined which gives the key to the manysided international film situation. That new slogan is "Trade Follows the Film," and there is a great element of truth in this modern-day expression.

The American-produced motion picture dominates world film markets, so much so that agitation has commenced in sixteen countries against the supremacy of the American film abroad. Foreign powers are today casting about to do something to restrain this influence. Aside from the moral influence of the American photoplay abroad, which in many instances gives a wrong or exaggerated impression of American life, it would appear that foreign legislation is against the trade advantages that the United States has enjoyed through the motion picture film and that much of this agitation against the American film has been caused by a certain amount of commercial jealousy because of the trade value of the huge film exportation from the United States.

For this reason and for other reasons which are apparent when one gives thought to the situation, foreign governments are taking a keen interest in the power of the motion picture film. This, to my mind, is a healthy sign, speaking generally. Once the governments of the world have awakened to the power of the film, the film medium will be utilized more and more in the years to come for various national and international purposes. Herein, I believe, lies a great opportunity which will raise the status of the entire motion picture industry to a much higher and more important plane.

On examining the uses of motion picture film by various world governments, we find an encouraging outlook and one which augurs well for the industry as a whole. During the World War the United States government and the various governments that compose the British Empire made wide and telling use of the film for governmental purposes. It instructed, it entertained war-torn soldiers and civilians alike, and it proved a marvelous medium for the dissemination of national information. Perhaps it was the World War that demonstrated conclusively the manifold uses of motion pictures for governmental purposes. At any rate since hostilities ceased, there has been no cessation by many governments in the use of films; on the contrary, there has been a decided quickening of activities along this line.

The United States, through its federal and state governments, is making a wide use of motion pictures. The importance of the film industry to the United States has been recognized by the establishment of a section or bureau within the United States Department of Commerce to deal with motion picture activities and watch developments in foreign markets of interest to the American film trade. A number of the state governments are making use of film for governmental purposes. Lieutenant-Governor Dennis Murphree of Mississippi recently addressed the Screen Advertisers' Association on "Selling Mississippi with Motion Pictures" outlining experiences which he has had in using films to advertise the state to its own people and to those from other communities. Many similar instances in the United States could be cited.

The British Government, through its Admiralty, has produced many informative and technical films and used them to splendid advantage in all parts of the British Empire. The recent tour of the Prince of Wales to South Africa and South America was completely covered by two camera men assigned by the British Government.

The Australian Commonwealth has lately been converted to the use of films for governmental purposes and has produced a series of informative short film subjects called "KNOW YOUR OWN COUNTRY." These films are being distributed at home and abroad to better acquaint the Australians themselves with their own country and to spread official and correct information abroad concerning Australia.

In France is being prepared under governmental auspices a series of films showing industrial activity, economic life, and scenic beauty of France. It is proposed to exhibit these films in the capitals of Europe, South America, and other countries. The pictures will be commented upon by lecturers speaking the language of the country where shown. It is announced that the French Foreign Office has already accomplished much toward the general development of the scheme. The project is designed to aid the people of other countries to better understand France and its people.

Another instance of the use and scope of this type of film work: The quaint little island-colony of Jamaica in the Caribbean Sea realized a few years ago that through the medium of the film she could attractively and aggressively display her charm and tourist lure. The Canadian Government Motion Picture Bureau was given a contract for the production of a series of one-reel informative films dealing with Jamaica. This series proved to be one of the chief attractions for visitors to the Jamaica exhibit at the recent British Empire Exhibition at Wembly, where they were shown for two years.

Mention should also be made of the film work of the Ontario provincial government. This provincial government maintains an up-to-date film laboratory and studio at Trenton, Ontario, with executive offices in Toronto, the capital of the province of Ontario. The government of the province of Ontario commenced producing films dealing with agriculture in 1917. These were distributed through the offices of the provincial agricultural representatives (corresponding to county agents), each of whom was equipped with a portable projection machine. The work was successful and gradually expanded. I am informed that during the past winter the province of Ontario circulated an average of 200 reels per day, 60% of which went to outlying parts of the province or sparsely settled agricultural districts.

The main object of the Ontario government in its film activities is to instruct and interest the people of that particular province in its resources and opportunities and at the same time to provide a certain amount of screen entertainment in agricultural areas. In order to take care of this entertainment feature of the work, a large number of purely entertainment reels were purchased, and the province now has a library of over 3,000 subjects.

The government of the Dominion of Canada is a pioneer in the use of motion pictures for governmental purposes. The Canadian Government has indeed realized that the motion picture screen is today more or less the world's blackboard and for the past nine years has been utilizing the film as a medium of informative international education. Some years ago it was realized that the world at large knew very little concerning Canada and that a great deal of ignorance and misconception existed not only in the mother country, the United Kingdom, but in many foreign countries concerning the vast empire situated north of the United States and stretching from the Atlantic to the Pacific.

Our experience with the use of the motion picture as a medium of international education, if I may use that phrase, to acquaint the world with the true story of Canada, its opportunities for the home-seeker, the capitalist, and the tourist, has been a success beyond the dreams of those who first saw the possibilities within the narrow strip of celluloid. Through the medium of the motion picture, it can be said that Canada is "selling" herself to the world. The enterprising merchant on Main Street uses his shop window to attractively display and sell his goods. Canada, through the aggressive and appealing use of the motion picture, is placing her wares in the world's "shop window."

Perhaps one of the chief ways in which the Canadian Government is making use of the motion picture from a national and international viewpoint is in connection with the development of the Dominion as a tourists' holiday land. In this field of federal endeavor, the pictures being produced by the Canadian Government Motion Picture Bureau are doing a work of far-reaching national influence. Canada's tourist trade has had a tremendous development within recent years and is now classed as the fourth industry of the Dominion. What more potent lure could influence the prospective tourist than the motion picture camera's portrayal on the screen of virgin hunting grounds and woodland forests, of splendid fishing lakes and rivers, of splashing brooks and leaping cascades, or fertile valleys and remote peaks floating snow-clad above the cloud-rack? We find from experience that it is in this national work of tourist trade development that the motion picture occupies a position of undoubted charm and impelling influence.

Another important part of our film work and one to which we are paying closer attention is the use of motion pictures by the Canadian Trade Commissioners in foreign countries. These trade scouts are stationed in various British and foreign countries throughout the world and motion pictures will be increasingly utilized by our Trade Commissioners to spread general information concerning Canada and to foster and encourage the development of Canadian trade abroad.

Governmental films are, in the final analysis, merely official government publications. Ordinary government publications are as a rule rather dry and musty. In producing and editing our "Seeing Canada" one-reel film subjects, we try to inject audience appeal and human interest. Government films prepared by this formula as a rule do not lie in film cans gathering dust and cobwebs. They are put to work. They get distribution and distribution is what is desired. But in the first instance these films must contain film material of real distribution value.

Will H. Hays, President of the Motion Picture Producers and Distributors of America, in a recent public address, in speaking of the internationalism of films, gives an illuminating glimpse into the possibilities of motion pictures from a world aspect. He said in part:

> Now let us go one step further—beyond the field of entertainment, beyond the field even of education—and regard for one moment what I personally believe may be the greatest opportunity for good possessed by the motion picture. It may be the greatest instrument for bringing about better understanding between man and man, between group and group, and between nation and nation. The motion picture knows no barrier of distance. We are apt to look upon the distant group or nation as something different from ourselves and therefore inimical. But a few thousand feet of celluloid film in a metal container can be sent to the ends of the earth to speak the language which every one understands, civilized or savage, the Language of Pictures.

I thoroughly agree with Mr. Hays when he says that thoughtful administrators of great nations of the world are coming more and more to realize these possibilities of the motion picture and are lending their aid to it in important ways. Surely, this is a healthy sign of the times and means much for the industry as a whole.

Judging the entire situation as it exists today, I have splendid hopes for the broadening use of the motion picture for governmental purposes because of its manifold advantages. I am sure that the day is fast approaching when every modern government will have its own motion picture bureau and will seriously undertake the work of making use of the potentialities of the motion picture for various governmental activities. A trail has already been blazed by a number of leading governments and I am sure that there is a splendid field of endeavor in this type of governmental film work and that the work will broaden in the years to come.

THE NATIONAL BUREAU OF STANDARDS AND ITS POSSIBLE TECHNICAL RELATIONS TO THE MOTION PICTURE INDUSTRY

George K. Burgess*

MOTION pictures are about as modern as the Bureau of Standards; both are twentieth century products. As an organized branch of engineering yours is ten years old, the youngest of the family. In 1900, motion picture photography was still in days of hit or miss. Progress in measured control has brought us a developed art. The new motion picture which will add color, stereo-relief, and sounds will be highly complex in its technical aspects. Standardization and measured control will then more than ever be indispensable; in fact, the trend in all industry today is toward complete measured control standardization.

We are in a period of astonishing progress in handling color, sound, and the three-dimensional handling of both lights and sounds. The acoustical counterpart of steroscopic vision now possible gives what we may call the "stereophonic" rendering of incidental sounds. Sounds are now transmissible without distortion and amplified without practical limit, and tonal reception is nearly flawless. Their successful photoelectric reproduction is reported. These possibilities are most interesting and important.

Photographic progress is hardly measurable in low percentages. Film sensitivities have been increased many fold for the longer waves by kryptocyanine. For indoor photography, red sensitization and quartz lenses (transparent to the more actinic wave lengths) have increased speeds from 600 H & D to 3000 H & D, or five times.

Before making a few constructive suggestions, may I remind you that the motion picture has already taken firm hold in science as a tool of great power. Motion study, the behavior of the slow process of growth in microbiology, the study of high-speed mechanisms, the scores of specialties are making excellent use of motion pictures. Science will increasingly use the motion picture for record, study, discovery, and instruction. In popularizing science, no method evokes greater interest than the motion picture.

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My theme is the possible contacts we may have with your field. Much of the data at the Bureau on light and color, photography and mechanics may be of value to you—physical constants, visibility curves, luminous efficiencies of light sources, and curves showing how light sources, dyes, filters, and special glasses emit, reflect, transmit, or absorb the visible or the actinic wave lengths. The Bureau's atlas of films and plates and their characteristics was the first published analysis of all current stocks available in America.

The Bureau has also studied the measurement of short intervals of time, shutter speeds, light sources, optical systems, optical glass, and fire hazards. An early study gave data for regulating steamship transportation of films. Highly concentrated arcs (900 candles per square millimeter) clearly require safeguarding. The Bureau's code for protecting the eyes of industrial workers is here of direct concern to the studio and projection operators though less serviceable to the actors exposed to intense lights without protection.

New instruments developed primarily for Bureau research may be of interest to you: a precision sensitometer for plates and films; equipments for precise colorimetry, photometry, and radiometry; new cameras for special uses, one to photograph flying bullets in a millionth of a second, another to photograph projectiles fired from big guns, another for photographing the complete exterior of corroded pipe; a research camera for developing photography through haze; and a target-practice camera which locates in three dimensions each shot in naval gun practice. The Bureau's method of photographing the entire interior surface of a rifle barrel is also to be tried out for photographing the interior of the bronchial tubes in clinical cases.

A good example of a fundamental achievement in Bureau research is a new filter recently produced which transforms ordinary long-wave incandescent light (below 3000°K) to the standard white at 5000°K approved by the International Congress of Photography as normal white defined by color temperature. Current researches are in progress on emulsions, ripening control, effects of added substances, causes of sensitivity, variations of characteristics with temperature, diffuse reflection, visibility of radiant energy, and many others.

Your problems ramify endlessly, but the single purpose—to render a scene on the screen in full motion, color, relief, and sound—is a natural basis for classifying the data needed to solve them. Color pictures are here to stay, to improve, to add realism, and to gratify the human sense of color. Such successful films as "Toll of the Sea," "Wanderer of the Wasteland," and the new Fairbanks film, "The Black Pirate," prove that color pictures are most effective and attractive. The arrival of color pictures calls for the solution of many similar problems of color definitions and specifications for materials and devices. Every technical aid should be given to perfect the color rendering. The improvement must come through accurate color measurements, data on photo-sensitivity to specific frequencies of spectral radiations, and the color properties of dyes, filters, and lights.

Accurate rendering of color effects will use all measured data and measuring devices to control color and color behavior, from the lights, costumes, and sets in the studio to the selective color sensitivities of film emulsions, color transparency of lenses, clear through to the color characteristics of the projector lights. For research on the constants of color and the color properties of materials, the Bureau's equipment is excellent, although funds and staff would be needed for new work.

How the Bureau may further serve the Society of Motion Picture Engineers as a group may best be illustrated by several actual cases in which the Bureau, upon request of engineering societies, rendered much needed and appreciated services. Funds and staff naturally limit the extent of such service.

Pure science is usually too abstract or intricate for direct application. Hence, the Bureau's service is chiefly through the expert. Advisory committees, comprising some 900 specialists, co-operate and confer with the Bureau on research programs and the validity of methods and results, and also assist in applying such results. The older branches of engineering, to which the Bureau owes its existence in no small measure, thus serve as advisors to the Bureau. Bureau experts, in turn, serve on technical committees of such societies. Contacts thus formed result in co-operative research for the mechanical, civil, electrical, mining, electrochemical, refrigeration, heating and ventilating, automotive, and other branches of engineering. The Bureau's facilites are, as far as means and staff permit, at your disposal for testing, research, information, standardization, or co-operative research.

The Bureau aided in putting science into lime making—modernizing an ancient craft. It devised a plastic gypsum. It showed cement engineers the great importance of fineness for high strength and found that calcium chloride would double the speed of hardening.

For the clay industry, it found ways to treat native clays to duplicate or excel the ceramic qualities of the best foreign clays. I might name many other cases.

For aviation the Bureau investigated and studied the theory and action of aviation measuring instruments in flight and in the laboratory, improving some forty of them, inventing others. These are the measured controls of the aviator. Only the flier knows how vital to his speed, safety, and effectiveness these instruments are. All other engineers have special instruments upon which success depends. The Bureau's publications "Radio Instruments" and "Aeronautical Instruments" are models of what the Bureau might eventually do for the measuring devices of the motion picture engineer. Numerous researches were also made on aviation touching almost every phase of this modern subject. The titles alone fill fifty pages of closely spaced typewriting.

The Bureau aids in definitions of units and terms used by the engineer. For the illuminating engineer, the Bureau's work on the candle power, unit of intensity, is notable. The gas and electric candle powers differed. The present uniformity at home and abroad is largely to be credited to the initiative of the Bureau. Researches for the electrical engineers culminated in international researches at the Bureau to define precisely the units and standards of electricity.

Having functions as broad as measurements, the Bureau's field grows naturally to cover new kinds of measurements. Engineers have new units. They must have also new standards with which to reproduce them. The long list of such standards (a score or more) made at the Bureau is an important service to engineers. Fuel engineers, for example, must standardize their combustion heat meters, calorimeters. For this purpose, pure materials of ascertained combustion heats are prepared, certified, sealed, and distributed as "Heat of combustion" standards. This is one example of many which might be cited.

Again—and this is an increasingly important service—the Bureau determines physical constants indispensable to success in science and industry, each numerical value playing its part as a service element no less than the tool or machine. For the refrigeration engineers, the Bureau determined and published the fundamental numerical data concerning the materials used in producing cold, so that branch of engineering now has a sound basis for computation and design. Years of experimental research were embodied in tables and charts which permit refrigeration problems which formerly required much labor for an uncertain result to be solved graphically with ease and accuracy.

The Bureau also computed and published fundamental petroleum tables for use throughout the industry. All branches of engineering likewise imperatively need accurate data, for errors vitiate design and operation however ingenious the one or skilled the other. What the Bureau has done for other branches of engineering, it has done in part for photography, color, illumination, sound, optical glass, optical instruments, and other subjects vital in your field.

Another enterprise might be a handbook of critical constants of motion picture engineering—definitions, equivalents, standards, and tabulated data for your use. Your society might initiate the movement and confer with suitable publishers as to the most effective plan for compilation and publication. It is possible that our experience in connection with the International Critical Tables may be of practical value in this connection. Such a reference work for the physical sciences is now in press, and it will be used daily in practically every research laboratory in the world.

The opportunity for physics and chemistry to aid motion picture engineering is a wide open door. The Bureau's efforts to serve you are limited by space, funds, and staff. Fortunately, Congress gave us one effective way to join forces—the research associate plan, of which I have brought you a descriptive circular. You may read the details at your leisure. Thirty or more national associations similar to your own maintain such associates. When a problem appears hopeful of practical solution, the Bureau provides quarters, general facilities, and co-operation. The Bureau laboratories supplement research facilities of those now conducting research and afford facilities for those who have none.

Your self-interest and the interest of your art properly demand the utmost that science can give. You know better than I the many technical problems which confront you with the introduction of relief, color, and sound. These involve technical physics—the particular field of the Bureau of Standards.

Your experience has led you to realize the need of classification. The sequence of operations involved is a natural outline for such classification. In 1921 Mr. Jones, of your society, published an excellent graphic analysis of the ten steps essential to reproducing an image, from the original object to the observed photographic reproduction. If extended to cover the newer phases of color, relief, and sound, it would make for motion pictures an excellent outline for a system like the Dewey Classification. The Bureau's published classification for radio has aroused interest and proved most helpful. A similar outline for your subject would facilitate the classification of data, literature, catalogs, researches, and, best of all, serve as a basis for a standard of process. For purposes of standardization, this cycle from the original set to final screen view should be treated as an organic and unified whole. The entire process leads to a single result—the screen picture. It should eventually have a completely interlocking standardization. Each item affects every other.

We analyze intensively so as to specify accurately the measured factors of successful service. Thirty thousand measurements perfect the functioning of an automobile. It would be interesting and fruitful to analyze the measureable details which ensure the perfect screen picture. The maxima and minima set for each such factor, when based on sound science, become a standard of practice. Such a standard assures screen pictures of uniformly high quality. I am glad to note that your work is taking an international turn. Standardization leads abroad and enduring standardization must be on a world basis.

Your industry, great financially, is even greater technically with its scope of subject, complexity, and world-wide use. Its newly developed auxiliaries give it an outlook unsurpassed for interesting possibilities. I am glad to meet your group which, through research and enterprise, is making the perfected motion picture of tomorrow.

The International Astronomical Union has a world program of fundamental research; adopts and defines its units and terms; allots the details of the program, so that twenty-four hours a day their frontiers are being pushed steadily forward. The noncommercial nature of the stars makes it easy for them. The whole world, however, is far more interested in motion pictures than in the stars and they surely merit equal consideration. Could you not formulate a program of fundamental research for your field? Your contact committee might then confer with the Bureau as to how these researches might be carried on.

May I urge that you enlist for your problems the active cooperation of the Bureau of Standards, which is your Bureau in a very real sense. It can confer with you. To it you can send or, better, come for tests or researches for short or long periods. A committee, perhaps an existing one, might serve as a contact committee and report on problems of mutual interest. May I leave with you the thought that the Bureau of Standards is your Bureau. Some of its greatest services have been for the newer arts, automotive engineering, aeronautics, and radio-communication. Perhaps we can be equally helpful in time to come in your fascinating field.

DISCUSSION

Mr. Richardson: There is one thing I believe the Bureau of Standards could do in the way of effecting a standard that would be very useful. During the past years I have had inquiries from many government officials, one from British Columbia, Saskatchewan, Philippine Islands, six or seven from different cities and states I can't name now, and one from England requesting information as to the difference in the heat of what is called the "spot at the aperture" of the motion picture projector with the ordinary arc and with the different light sources now being used. I put that up to your department something like two years ago. It was promised something would be done, but up to the present I haven't heard of any results having been attained.

The heat at the spot with all the light sources used is so great that the intense heat dries the film very rapidly, and if a fire occurs and the projectionist is not there, the fire will follow the film more rapidly and readily and is much more likely to get through to the upper magazine. This is hardly probable with the modern projector if everything is in order, but it is not always in order. I believe your department might, by experiment, determine what is the maximum amount of heat permissible at the spot, considering the effect on the film itself, and set this up as a standard. I believe this can be done: also, that the heat at the spot can be controlled without affecting the amount of light. I suggest to you for consideration the matter of working out a standard of the kind I have suggested.

Mr. Hill: Mr. Richardson has just said that some two years ago we began to investigate the matter of heat on the film. I can't make any official report at this time, but all light sources of sufficient strength for theatre use will ignite the film before anybody can do anything about it, so it really doesn't matter just what fraction of a second is required in different cases.

The real substance of the information we got from our work is this: Film is a poor conductor of heat, and if the projector mechanism is kept cool, there is little danger of the fire spreading beyond the aperture. In our laboratory here we have burned initials in a film without igniting it, which shows pretty conclusively what can be done by heating the film in one place only. In an optical system where the film and nothing else is illuminated there is very little fire hazard, and I believe this to be the ultimate solution. The optical system we use has already been described to the Society.* In no case since we adopted this system have we had any serious fire, and as far as I know, no fire has ever spread beyond the film aperture.

Mr. Loyd Jones: I might say that we have in progress at the present time quite a program of measurements on the heating of film under various conditions. Mr. Richardson has mentioned this many times before, and I suppose he thinks the research man is very slow in getting information, but a problem of this kind has so many variables that a thorough investigation is a rather long problem. While we have nothing which we are willing to say at the present time, I think in another six months or a year at the most, we will have available some comprehensive information on the subject. I do not mean to discourage others from making measurements but thought that Mr. Richardson might like to know something is being done.

Dr. Sheppard: One point is the relations between the Bureau of Standards, technical societies, and other research organizations. The present offers some opportunity of framing more definitely the relations which might exist between a body like this and the Bureau of Standards. Dr. Burgess referred to pamphlets dealing with research associates. As I understand it, the idea is that selected persons from a given industry should carry out researches at the Bureau, but I think we want some kind of definite scheme of interchange of work without overlapping, although we need some overlap. We don't want to waste energy in carrying out investigations. Certain problems want to be brought forward by such a society as this. The suggestion of the last member that the frontier should be sketched is good in itself in defining this, but I think the problem proposed is a little too general to expect any one man to cover it. But I think we could have some machinery of selecting; for instance, our Progress Committee might select certain problems having a

* "A New Unit for Professional Projection with Tungsten Filament Lamps," Transactions S. M. P. E. No. 20

vital, topical importance and proceed to get an exchange of opinion and suggest who should do this and how much in different places. I put this forth as a constructive suggestion as to how we are to take advantage of the different existing organizations and which of them do research work in our industry. We all regard the Bureau as the standard authority; we refer to it on light sources, etc., as the last word, but we also want to have a clearing house for the problems. That is a suggestion which could be discussed in committee rather than generally, but some one might have definite ideas on it.

SILVER RECOVERY FROM EXHAUSTED FIXING BATH

J. I. CRABTREE AND J. F. ROSS*

IN A motion picture laboratory, the fixing bath for positive film is usually discarded after fixing approximately 1000 feet of film per gallon of solution. Such a bath will contain a little more than an ounce of silver per gallon, which at the present market price is worth about $0.65. The exhausted fixing bath, may, therefore, contain about $0.75 worth of silver per gallon; in other words, for each million feet of positive film processed, about $750.00 worth of silver is lost in the fixing bath.

In the case of negative film, almost twice as much silver is dissolved out of the emulsion into the fixing bath, but owing to the slower rate of fixation a negative fixing bath is usually discarded after processing only about 500 feet per gallon. The silver content per gallon is, therefore, approximately the same as for an exhausted positive bath, though the amount of recoverable silver per million feet of negative film is about 75% greater than for positive film.

The above figures are very approximate because the amount of silver halide dissolved out by the fixing varies inversely as the amount of silver which constitutes the developed image. For example, a fixing bath used for negative titles (on positive film) will contain much more silver than one used for the same footage of positive titles.

There is also some loss of silver by virtue of the fixing bath carried over by the film into the wash water. This loss can be minimized by using a rinse bath after fixing and adding this rinse water to the hypo for recovery.

The actual financial return consists of the value of the silver recovered minus the cost of recovery, shipping, and refining charges. The cost of recovery depends upon the method used and the labor involved, while the shipping charges are minimized by shipping only large quantities of dried sludge. The assay charges vary from $5.00 to $10.00 for each shipment of sludge, and it is therefore more economical to send a maximum quantity of sludge in one shipment. Most refiners deduct 10% of the value of the recovered silver as their fee.

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Silver recovery by precipitation methods is never 100% efficient because of losses due to (1) incomplete precipitation, (2) incomplete separation of solution and precipitate, (3) the adhesion of sludge to drying containers and filters, and (4) inefficiency in refining. Other deductions from the actual value of the silver can be approximately figured as (1) cost of recovery, 5%; (2) cost of shipping, 2%; (3) cost of refining, 10%. It is thus seen that the actual cash return cannot exceed approximately 75% of the value of the silver originally present in the hypo solution.

For large scale recovery the sulphide method is almost universally employed in motion picture laboratories although several new methods of recovery have recently been suggested including precipitation with zinc dust, sodium hydrosulphite, or electrolytic methods, and the relative merits of these methods seemed worthy of investigation. Also, a number of concerns have undertaken to extract the silver and return the so-called recovered bath to the consumer to be used again. The advisability of attempting to use such a recovered bath seemed questionable at the outset but merited investigation.

Nature of an Exhausted Fixing Bath

Four modifications of the thiosulphate fixing bath are in common use at the present time, as follows: (1) a plain solution of sodium thiosulphate or hypo, (2) hypo plus sodium bisulphite, (3) hypo plus an acid alum hardener and (4) hypo plus a chrome alum hardener.

The chemical components of an acid-alum fixing bath are: sodium thiosulphate, sodium sulphite, potassium alum, and acetic acid; a typical formula is as follows:

Acid Hardening Fixing Bath

(Formula F-2)

Hypo	250 grams	105 lbs.
Water to make	1 liter	50 gal.

Add 50 cc. per liter or 2½ gallons per 50 gallons of the following hardener:

Potassium alum	120 grams	50 lbs.
Acetic acid (glacial)	100 cc.	5¼ gal.
Sodium sulphite(desiccated)	60 grams	25 lbs.
Water to make	1 liter	50 gal.

A chrome alum fixing bath contains sodium thiosulphate, sodium sulphite, potassium chrome alum, and sulphuric acid.

When a fixing bath is used, developer and developer oxidation products, sodium silver thiosulphate, sodium bromide, sodium sulphate and basic aluminum sulphites, and occasionally free sulphur accumulate therein. An exhausted fixing bath is therefore a relatively complex solution.

In order to compare the various silver recovery processes on an equal footing, it was necessary to choose a definite standard of exhaustion for a fixing bath. It was found that after fixing 500 feet of Eastman negative motion picture film having a normal exposure in 1 gallon of the above fixing bath, the time to clear had been more than doubled, and the silver content of such a bath was approximately 1 ounce (avoir.) per gallon, or 7.5 grams per liter. This silver content was taken as a standard.

METHODS OF SILVER RECOVERY

The following methods of recovery were studied:

A. Precipitation with sodium sulphide
B. Precipitation by means of zinc
C. Precipitation wth sodium hydrosulphite
D. Electrolytic methods

A. The Sulphide Method

The method consists essentially of adding sodium sulphide or liver of sulphur to the fixing bath, when the silver is precipitated as silver sulphide. The chemistry of the reaction may be expressed by the following equation:

$$Na_2S + Na_4Ag(S_2O_3)_3 = Ag_2S + 3Na_2S_2O_3$$

Sodium sulphide + sodium silver thiosulphlate = silver sulphide + sodium thiosulphate

The efficiency of the method is quite high owing to the fact that silver sulphide is the most insoluble of all the common salts of silver.

The objection to this method of precipitation is the offensive odor of the hydrogen sulphide evolved if the fixing bath is acid, the acid causing decomposition of the sodium sulphide. Since fumes of hydrogen sulphide affect sensitive photographic materials, thus causing fog, such gases must not be evolved if there is a possibility of their entering the laboratory. This can be insured by making the bath alkaline with caustic soda before adding the sodium sulphide. This process of neutralization adds considerably to the expense but is absolutely necessary if the precipitation is carried out in the laboratory building. If the recovery plant is remote from the building, neutralization is not necessary, but even in this case, in a populated district, the objectionable odor of the hydrogen sulphide might be termed a public nuisance, and neutralization would be necessary. The following instructions for precipitation of silver with sodium sulphide include the neutralization of the bath, but if the odor of the hydrogen sulphide is not objectionable, the neutralization should be omitted.

Instructions for Recovering Silver by the Sulphide Method

Place the exhausted hypo in a suitable container, such as a wooden tank elevated slightly from the floor to facilitate draining. Place a strip of red litmus paper in the solution. If it remains red the solution is acid, but if it turns blue the solution is alkaline. Most exhausted baths are slightly acid, and they should be neutralized with a solution of caustic soda (sodium hydroxide) prepared by dissolving commercial caustic soda in cold water in the proportion of 2 pounds (900 grams) per gallon (4 liters). The solution becomes very hot during mixing. If hot water is used for dissolving the solid chemical, so much heat is evolved that the solution is apt to boil with explosive violence. *Caustic soda is very corrosive, and care should be used in handling both the solid chemical and the solution.*

Add the caustic soda solution to the hypo in the proportion of 1 ounce per gallon of hypo, stir well, and test with litmus paper. If the solution is not alkaline, continue to add the caustic solution until a strip of litmus paper turns blue. Then add about one-fifth of an ounce of the caustic solution per gallon (1½cc. per liter) in order to insure distinct alkalinity.

As the neutralization with caustic soda progresses, a light colored flaky precipitate will form if the fixing bath contains an alum hardener. This precipitate generally dissolves when the bath becomes distinctly alkaline. The disappearance of this precipitate is a good indication that the bath is sufficiently alkaline, but the litmus paper test is more satisfactory. Then, to each gallon of hypo solution add 1 ounce (30 cc.) of sodium sulphide solution prepared by dissolving the fused salt in the proportion of 2 pounds (900 grams) per gallon (4 liters) of hot water. *This should be prepared away from the dark room because hydrogen sulphide gas is liberated on dissolving the sulphide, which will fog sensitive photographic materials.*

Stir the solution thoroughly and test for the presence of silver by filtering a small volume and adding a little sodium sulphide solution to the clear filtrate. Any precipitate which forms, indicates that the silver precipitation is incomplete. It is necessary to continue additions of the sulphide solution to the bath until this test gives a clear solution, and no brownish black precipitate forms.

The presence of an excess of sulphide can also be determined by means of strips of test paper prepared by soaking strips of blotting paper in a 10% solution of lead acetate or lead nitrate. The strips may be used either wet or dry. In making the test, dip a strip in the solution and remove immediately. If the paper turns uniformly black, there is an excess of sulphide in the solution, which in turn indicates that all the silver has been precipitated.

Allow the bath to stand overnight, so as to permit the silver sulphide sludge to settle out completely and drain off the clear liquid by means of the draining spigot or syphon. In large motion picture laboratories it is customary to have several storage tanks, some of which are being filled with exhausted hypo while the silver sulphide sludge is settling in others. Several precipitations are usually carried out in one tank before the silver sludge is removed. In order to prevent the possible loss of silver contained in the supernatant liquid, this is drained into a second or third settling tank from which it is passed into the sewer.

Handling the Sludge

Small quantities of sludge may be dried by exposing to the air in flat trays. Moderately dry sludge may also be mixed with sawdust for shipping purposes. The sludge is removed manually from the large precipitation vats by means of shovels and packed in watertight barrels or dried on trays in a drying oven.

When submitting silver residues, a fixed assay charge is made regardless of the quantity shipped. It is important therefore not to submit the residues to the refiner until a quantity has accumulated that will make the shipping and refining charges but a small percentage of the value of the silver recovered.

Composition of Sludge

The dried sulphide sludge consists mainly of silver sulphide and hypo, the quantity of the latter depending upon the thoroughness of draining. If the precipitation is carried out in a solution which is only slightly alkaline, the sludge will contain compounds of aluminum, but these will not be present if the bath was distinctly alkaline before precipitation. If precipitation is carried out in acid solution, the sludge will contain free sulphur. The sludge from a chrome alum fixing bath will also contain chromium hydroxide if it is made alkaline before recovery. Various silver sulphide sludges tested contained from 40% to 70% of silver.

B. The Zinc Method

Zinc is a very efficient material for displacing silver from solution. When it is added to an exhausted hypo bath, the chemistry of the reaction may be expressed by the following equation:

$$\underset{\text{Sodium silver thiosulphate}}{Na_4Ag_2(S_2O_3)_3} + \underset{\text{zinc}}{Zn} = \underset{\text{silver}}{2Ag} + \underset{\text{zinc thiosulphate}}{ZnS_2O_3} + \underset{\text{sodium thiosulphate}}{Na_2S_2O_3}$$

Precipitation with zinc has a distinct advantage over the sulphide method in that it is not accompanied by the liberation of disagreeable or harmful gases.

The zinc may be employed in 3 forms: either as zinc dust, granulated zinc, or sheet zinc. Of these, only zinc dust is of value for large scale recovery, because the rate of precipitation of the silver with both granulated and sheet zinc is too slow.

Although zinc dust will precipitate the silver satisfactorily in either acid or alkaline solutions, the best results are obtained if the solution has an acidity equivalent to 1 ounce of acetic acid per gallon (7 cc. per liter). For rapid recovery it is also necessary to agitate the bath frequently. When the recovery bath is neutral, a foam which contains silver is formed on top of the solution, so that some silver is apt to be lost on draining.

The method outlined below is the most efficient although possibly not the most economical. The adjustment of the acidity by means of acetic acid can be omitted. For other conditions of acidity, the recovery might require a longer time and also more frequent stirring.

Instructions for Recovering Silver by the Zinc Dust Method

Place the exhausted hypo in a suitable container such as a wooden tank which is elevated to permit of easy draining. Test the acidity or alkalinity of the solution by means of litmus paper. If the bath is acid, a strip of red litmus paper will remain red when placed in the solution, but blue litmus paper will turn red. Most exhausted baths are acid, but if the tests indicate that the bath is alkaline (red litmus turns blue, and blue litmus remains blue), it should be made acid by adding a sufficient quantity of glacial acetic acid. In case the bath is acid (or after it has been made acid), add a further quantity of glacial acetic acid in the proportion of one-half ounce (15 cc.) to each gallon (4 liters) of hypo. The bath is then ready for precipitation of the silver.

Slowly add the zinc dust to the bath with vigorous stirring in the proportion of two-thirds of an ounce per gallon (5 grams per liter). After all the zinc dust has been added, stir the bath for two or three minutes and then allow to stand over night. Unless the fixing bath was heavily loaded with silver, the precipitation will be complete after standing for sixteen to twenty-four hours, but it is well to test for completeness of precipitation. Remove a small volume of the clear hypo and place a bright strip of copper in it. If after standing one minute the copper is covered with a silvery coating, the silver has not been completely precipitated, but if the metal simply darkens slightly and does not take on a silvery appearance, the silver has been completely precipitated.

Another method of testing for completeness of precipitation is by means of sodium sulphide. Take an ounce (30 cc.) of the clear bath, add about one-fifth of an ounce (6 cc.) of glacial acetic acid and about the same volume of a 20% sodium sulphide solution. The formation of a very dark brownish black precipitate indicates incomplete silver precipitation, while the lack of a dark precipitate indicates complete precipitation. In case the precipitation is not complete (which seldom occurs), add zinc dust in the proportion of about one-fourth of an ounce (8 grams) per gallon (4 liters) and stir. After standing a second day, precipitation will be complete.

Drain away the clear (or slightly opalescent) liquid by means of the draining spigot or a syphon. The remaining silver zinc sludge should then be dried in the manner outlined under the "Sulphide Method."

Composition of Sludge

The final dried sludge from an acid recovery bath contains silver (probably sulphide), free zinc, and sodium thiosulphate, the amount of the thiosulphate depending upon the thoroughness of draining of the sludge.

The sludge from the neutral recovery bath will contain silver (sulphide), free zinc, zinc hydroxide, basic aluminum sulphites, and thiosulphate. In an alkaline recovery bath, the basic aluminum sulphites remain in solution, but the percentage of zinc hydroxide in the sludge is greater. The aluminum compounds will not be present in any case unless the original hypo bath contained an alum hardener.

The percentage of silver in the sludge is dependent on the silver content and the acidity of the hypo bath, which control to a large extent the quantity of free zinc present in the sludge. The controlling factors are so numerous that it is difficult to state a probable silver content, but this generally falls between 15% and 40% silver for the dried sludge.

Relative Merits of the Zinc and Sulphide Methods

From an economic standpoint there is very little difference in the cost of the chemicals required for the zinc or sulphide methods. For recovering the silver from one hundred gallons of bath by the sulphide method, the cost (wholesale) of the sodium sulphide is $0.30 and that of the caustic soda also $0.30. If the bath is not neutralized, the latter cost is eliminated.

With the zinc method the costs are $0.40 for zinc dust and $0.30 for acetic acid. The addition of acetic acid is not essential, but in the absence of this additional acid the rate of precipitation is not so rapid. The labor costs by the zinc method are slightly greater, since it is necessary to stir the bath at intervals either manually or by means of a mechanical stirrer. Also, the precipitated silver does not settle quite as rapidly, since it is apt to remain in suspension as a result of effervescence caused by the evolution of hydrogen produced by the interaction of the zinc and acid.

*C. The Sodium Hydrosulphite Methods**

The use of sodium hydrosulphite to recover silver from used hypo baths was first described by Steigmann[1] in 1921. He explains the chemistry of the reaction by the following equation:

* Note: Strictly speaking, the compound $Na_2S_2O_4$ should be called "sodium hyposulphite," but, as this is the name which photographers use incorrectly to designate $Na_2S_2O_3$, or sodium thiosulphate ("hypo"), in the present investgation the term "hydrosulphite" will be used for the compound, $Na_2S_2O_4$.

[1] "A new Photographic Silver Recovery Process," A. Steigmann, Koll. Zeit., *28*, 175 (1921).

$$2NaAgS_2O_3 + Na_2S_2O_4 = 2Ag + 2Na_2S_2O_3 + 2SO_2$$

Sodium silver thiosulphate + sodium hydrosulphite = silver + hypo + sulphur dioxide

Firth and Higson[2] have analyzed various silver residues obtained by the precipitation of silver from hypo solutions with hydrosulphite, and they explain the reaction by the following equation:

$$2NaAgS_2O_3 + Na_2S_2O_4 = Ag_2S + Na_2S_4O_6 + Na_2SO_4$$

Sodium silver thiosulphate + sodium hydrosulphite = silver sulphide + sodium tetrathionate + sodium sulphate

The appearance of the precipitate (obtained in alkaline solution), which is black and very dense, would indicate that it was metallic silver, but analyses of some of the washed precipitates showed that they contained both silver and silver sulphide. Tests with this method showed that the bath must be made alkaline and the precipitation carried out at a temperature of 50° to 60°C. (120° to 140°F.) for most efficient results, although by using a mixture of sodium hydrosulphite and sodium sulphite it is not necessary to make the bath alkaline. When the precipitation is conducted at ordinary temperatures, one to two days are required to completely precipitate the silver.

The chief objection to methods of recovery with sodium hydrosulphite or its derivatives is the relatively high cost in comparison with the zinc and sulphide methods. Precipitation is no more complicated, while the silver precipitate obtained is more compact than that given by any other precipitation process. Proponents of this method have claimed that the high cost of the hydrosulphite is offset by the fact that the fixing bath is rejuvenated. Since it is inadvisable to attempt to utilize a fixing bath after recovery by any of the methods described later, this factor is of no importance. Unless the present price of hydrosulphite can be reduced, this method does not possess sufficient advantages over the zinc or sulphide methods to justify its general adoption.

D. Electrolytic Method of Silver Recovery

It is a very difficult matter to satisfactorily electroplate the silver out of an exhausted fixing bath in the metallic condition by the usual methods of electroplating. If the voltage is carefully regulated so that the potential between the electrodes is around

[2] "The Action of an Aqueous Solution of Sodium Hyposulphite on Silver Chloride," J. B. Firth and J. Higson, Jour. Soc. Chem. Ind., *42*, 427 T (1923).

0.7 volts, metallic silver is deposited, but only very slowly. If the voltage is raised above 1.0 volt, a sludge of silver sulphide forms at the negative electrode and throughout the solution due to a reaction between the hydrogen liberated at the cathode and the thiosulphate ions. The reaction can be expressed by the following equation:

$$2Ag^{+} + S_2O_3'' + 8H^{+} = Ag_2S + H_2S + 3H_2O$$

$$\text{Silver} + \text{thiosulphate ions} + \text{hydrogen ions} = \text{silver sulphide} + \text{hydrogen sulphide} + \text{water}$$

Attempts were made to precipitate the sulphide at the cathode and retain it there by the use of a porous cup, but the method proved unsuccessful. More sulphide is formed than is used up by the silver at the cathode, and this excess sulphide diffuses into the main bulk of the solution and precipitates silver sulphide.

An investigation into the costs of electrolytic precipitation revealed that with the cost of electric power at 1.5 cents per kilowatt hour the cost of the current required to precipitate the silver from one hundred gallons of exhausted hypo was approximately $3.00. In comparison with the costs involved with the zinc and sulphide methods, this figure is prohibitive. Since electrolysis usually precipitates the silver as sulphide, it is obviously much cheaper to use chemicals for the precipitation.

Electrolytic Units

Within recent years two commercial electrolytic units have appeared on the market, one of which consists essentially of a number of zinc plates and a copper plate bound together but insulated from each other. The second type consists of a zinc plate and a bag of copper ribbon connected externally by a metallic wire. When the latter unit is placed in an exhausted hypo bath, silver is displaced by the zinc, and a silver-zinc cell is set up which causes the deposition of silver on the copper, and the zinc passes into solution. The current set up by the units is sufficiently low to insure the deposition of silver and not silver sulphide.

Although it has been recommended that electrolytic units should be placed in the fixing bath while it is in use, whereby the fixing life of the bath is prolonged by virtue of continual removal of silver, this procedure is not of commercial importance. The hypo bath is somewhat revived by the removal of silver by the units, but it is not rejuvenated to such an extent that its properties approach those of a fresh bath. The units cause bad sludge formation if they are placed in a working acid fixing bath unless the bath is well loaded with silver, and even in this case an appreciable quantity of sludge will form.

The value of electrolytic units lies in their use as silver recovery media; that is, for depositing silver from discarded fixing baths. For treating moderate quantities of solution, the units are very efficient and require a minimum of labor since the operations of precipitation, filtration, or decantation and drying of sludge are unnecessary.

PROPERTIES OF DESILVERED HYPO

An exhaustive series of experiments has been carried out to determine the properties of desilvered hypo in comparison with those of the original bath and to investigate the advisability of utilizing such a recovered bath. In this article only practical conclusions will be given. Complete experimental details will be given in a more exhaustive paper published in the 1927 edition of the American Annual of Photography.

At the outset it was realized that mere revival of the rate of fixation by removal of the silver does not imply rejuvenation of the bath. The revived fixing bath should possess all the desirable properties of a fresh fixing bath with regard to rate of fixation, degree of hardening of the gelatin, sulphurization and aluminization life, and non-staining properties. The useful life of the revived bath as measured by the quantity of film which may be successfully fixed therein as compared with the useful life of the original fresh bath is a measure of the degree of rejuvenation.

A fresh acid fixing bath contains hypo, acetic acid, sodium sulphite, and potassium alum. With use, apart from the accumulation of the silver compound $Na_4Ag_2(S_2O_3)_3$, providing an acid rinse bath is not used, the bath also accumulates developer which is carried over by the film. This causes neutralization of the acid and an increase in the sulphite content, which affects the hardening properties. If the bath becomes alkaline the developer oxidizes and stains the bath, while in hot weather if the acidity is too high the bath may contain colloidal sulphur.

Previous experiments have shown that the hardening properties of a fixing bath may be partially revived by restoration of the original acidity, but the degree of hardening obtainable is less than that of the original bath because the balance between the proportions of acid, alum, and sulphite has been destroyed due to the presence of an excess of sulphite from the developer carried over. A partial restoration of the hardening properties is, however, effected by re-acidifying the bath at intervals.

The problem is also complicated by the possible presence of an excess of precipitant used to remove the silver. The desilvered bath may contain (a) sodium sulphide, (b) zinc acetate and zinc thiosulphate, or (c) sodium hydrosulphite, depending on the recovery method used. Also, in the case of the zinc method of recovery, except with a strongly acid bath, practically all the alum is removed. With the other methods most of the alum remains, except with a chrome alum bath, when the chromium is precipitated in alkaline solution. Most of the hypo baths after removal of the silver are either neutral or alkaline in reaction.

The properties of the desilvered hypo obtained after treatment by a few of the most important silver recovery methods were studied to determine the possibility of successfully utilizing desilvered hypo for fixing purposes, and the following conclusions were arrived at:

A. In all cases the fixing bath is more or less rejuvenated as regards the time of fixation by virtue of removal of the silver, though for reasons given below the bath is not necessarily in a condition suitable for use.

Such desilvered baths, however, do not harden the film. If sufficient hardener were added to revive the hardening properties, the desilvered baths would fix much slower. The effect of the addition of the hardener constituent on the time to clear is shown in the following table:

Time to Clear Motion Picture Negative Film at 65°F. (18°C.)

Formula F-2 without Hardener	*Formula F-2 with Hardener*
4¾ minutes	6¼ minutes

The concentration of hypo was adjusted so as to be equal in both baths to compensate for the dilution of the bath with the hardener solution. Further experiments on a practical scale indicated that after removal of the silver by the sulphide method and partial restoration of the hardening properties by further addition of hardening constituents, the rate of fixation of the bath was not restored. It was necessary to add a further quantity of hypo equal to 50% of the original concentration before the rate of fixation approximated that of the original bath. These facts can be explained as follows:

With use, the rate of fixation falls off due to (a) removal of active thiosulphate ions by virtue of the formation of complex silver thiosulphate ions, (b) the dilution of the fixing bath due to addition of developer or rinse water and removal of hypo by the film, to the wash water, (c) the accumulation of sodium iodide. The effect of traces of potassium iodide in retarding the rate of fixation has been investigated by Strauss,[3] and his results have been confirmed.

Removal of the silver by precipitation may, therefore, convert the silver complex ions to plain thiosulphate ions, but the desilvered bath is more dilute than the original and still contains iodide. This explains why it is necessary to add such a large additional quantity of hypo (50% of the original) in order to revive the bath with regard to rate of fixation. No practical method is known for removing the iodide.

B. It is quite possible to produce a desilvered bath with non-staining properties. In the case of the sodium sulphide method the presence of 1½ grains of sodium sulphide per gallon (0.025 grams per liter) in the desilvered fixing bath will cause the immediate precipitation of silver sulphide on the emulsion in neutral or alkaline solution. It is almost impossible to completely precipitate the silver without having a much greater excess than this quantity of sulphide present in the solution. If the hypo is acidified after removal of the silver from a bath containing a large excess of sulphide, sulphur is precipitated.

In order to insure the absence of free sulphide in the desilvered bath, when precipitating the silver it is desirable to use as small an excess of the precipitant as possible and then add a further quantity of exhausted bath until the bath no longer gives a test for sulphide with lead acetate paper.

C. The sulphurization life of all desilvered baths tested was satisfactory.

D. The process of desilvering invariably destroys the hardening properties of the bath, as would be expected, since the critical ratio between the proportions of acid, alum, and sulphite has been

[3] "The Fixing Bath and Time of Fixation," Strauss, Phot. Ind., Aug. 17. 1925, p. 911.

destroyed. When the bath is made alkaline during the recovery, the alum is precipitated and often does not completely dissolve to form sodium aluminate unless a large excess of alkali is used. In most cases, however, it is possible to restore the hardening properties by adding a further quantity of the acid hardening solution used for compounding the original fixing bath. On adding the original quantity of hardener although the hardening properties are restored, the fixation life of the bath is inferior. In order to revive it, it is necessary to add 50% of the original quantity of hypo, but even then the fixation life is only 75% of that of the original.

Practical Recommendations

1. For silver recovery on a large scale, of the various possible methods, precipitation with sodium sulphide is the most economical. Precipitation with zinc dust, although not so rapid, is efficient and has the advantage that no objectionable fumes of hydrogen sulphide are evolved as in the sulphide process.

2. Although it is possible in the hands of a capable chemist to so restore a fixing bath by desilvering, subsequently clarifying, and modifying its composition that its useful life is prolonged, it is just as economical and far preferable to prepare a fresh bath. In order to revive a bath after desilvering, it is necessary to add a further quantity of hardener equal to that originally used and also a quantity of hypo equal to 50% of the original quantity used. The resulting bath has approximately only three-fourths the life of a fresh bath and is, therefore, just as expensive.

Generally speaking, no saving whatever is effected by utilizing a desilvered and revived hardening fixing bath at the present low market cost of hypo in comparison with the value of the sensitive materials fixed therein. Moreover, it is false economy to risk the possible destruction of valuable sensitive materials and the production of images of questionable permanency by using desilvered hypo.

DISCUSSION

Mr. R. Hubbard: I understood Mr. Crabtree to say that the maximum amount of silver which could be recovered was a litte`less than a thousand ounces per million feet. In practice we have been unable to get that. It may be due to the dishonesty of the refiner. In some cases we have got approximately that for a long period of time, and at other times it has fallen away below that. I just wanted Mr. Crabtree to make it plain what might be the cause for that.

Mr. Crabtree: It is possible to give only very rough figures. The amount of silver recovered is inversely proportional to that in the developed image, so that it may vary from approximately two hundred to eight hundred ounces per million feet depending on the nature of the subjects photographed.

THE HANDLING OF MOTION PICTURE FILM UNDER VARIOUS CLIMATIC CONDITIONS

Robert J. Flaherty

IT HAS been suggested that the Society of Motion Picture Engineers might be interested in my experiences in handling motion picture film under various climatic conditions; namely, those I encountered during the time I spent in the North making "Nanook of the North" and during the past two years making "Moana" in the South Seas. We shall not have proceeded very far with this paper before you will understand that my experiences are those of one who has had no technical training and whose entire experience has been gained outside of the laboratories and studios of the motion picture industry. However, it is to be hoped that that which follows may to some extent be illuminating.

From the year 1910 to 1916, I carried on geological explorations in the eastern sub-Arctic, and during the latter half of these expeditions I became interested (although only as an amateur) in motion picture films, taking as a minor part of my exploratory work such subjects as came within the range of my camera. Needless to say, they were not of any importance or value. When I decided to make "Nanook," I had a definite plan in mind; that is, to go back into the North equipped for a year and a half and devote my entire time to working out the life story of the Eskimo, which, as I have mentioned before, became "Nanook of the North." I realized from the start that in order to work out my subject effectively I must have not only the equipment for developing my negative but apparatus both for printing and projecting, so that I could see my results in order to correct them and retake whatever might be necessary.

Transportation was the first problem, for the journey to the point where I proposed to work—Cape Dufferin, on northeastern Hudson Bay—involved a journey by canoe down to southeastern Hudson Bay, making economy of weight and bulk imperative. For my projecting equipment I chose a Hallberg generating set and Hallberg's suitcase type of projector, an outfit which Hallberg had designed for mule back transportation in the South American market. This outfit, which gave a good account of itself, was portable to the last degree, the apparatus complete—engine and dynamo—

weighing less than a hundred pounds. For printing apparatus I used a Williamson wall-type printer; for developing, four 200-foot capacity spider frames made of brass, the pins insulated with rubber tubing, and four 15-gallon capacity copper trays. I am still looking for the man who invented those spider frames, for a more laborious method of developing film (the loading of a 200-foot unit alone was a fifteen-minute operation) I have never seen. The danger of overlapping of the film while in the developer required almost constant supervision, making my experience in developing some 70,000 feet of negative and 20,000 feet of print an unforgetable one.

The point where I decided to winter and undertake the film was the fur post of Revillon-Frères near Cape Dufferin on northeastern Hudson Bay, as the crow flies, 900 miles north of the railway frontier of northern Ontario. The post comprised a store, a factor's house, and a clerk's dwelling. The last named, a single story hut about 30 by 30 feet, was turned over to me to be used as a dwelling and laboratory combined. The man power of the place was one white man (the factor) and some half dozen Eskimos. The Eskimos lived on sea biscuit, lard and tea, and were given a not too opulent wage, amounting to less than five dollars a month, and were maintained by the factor as his servants. Three of them, since I had come into the country without an assistant, were turned over to me to be my servants. These were Nanook and two lesser individuals bearing the somewhat grotesque nicknames of "Harry Lauder" and "Matches." Our first job was to partition off with scraps of lumber and rubberoid a portion of the hut for a dark-room, 6 by 15 feet in dimension. At one end was a window which we banked up with rubberoid and then on a board frame mounted the Williamson printer, first cutting an inlet about two inches square to admit light, for by daylight controlled by nothing more accurate than white muslin stretched over the aperture, the prints of "Nanook" were made. There was no motor drive on the printer. Every print was ground out by hand. I printed, all told, about 20,000 feet in that memorable year. But the darkroom and its impedimenta were simplicity itself in comparison with the lengths to which I had to go to provide some sort of place for the film drying and washing. With the most meager resources as to lumber (what little I could carry on the sixty-foot schooner on which I had journeyed) we built a wing to the hut some twenty feet long and ten feet wide and then a drying reel whose 1600-foot capacity was such as almost to fill the room. For heat we had a discarded box stove and for fuel nothing more adequate than bituminous ship's coal! Under such conditions the 70,000 feet of negative and 20,000 feet of print (pardon me if I repeat the figures) were dried, the reel kept in motion only by the strong arms of Nanook or Harry Lauder and sometimes, depending on the weather, kept in motion, more or less, the whole night long while I slept in my sleeping bag just beyond cremation range. Our source of water for washing the film was the river sealed with eight feet of ice through which a water hole was kept chiseled every morning and night of the winter. From the hut this hole was a quarter of a mile away, so by sledge and dogs the water in ice choked barrels was sledged by the womenfolk and children of Nanook's and Harry Lauder's families with much laughter, much shouting, and a fight now and then among the team. The number of barrels we wrestled with that long year can be imagined.

My camera equipment consisted of two Akeley cameras, some minor spare parts, and ten 200-foot capacity retorts. There were also one 4x5 and one 2¼ x 3¼ Graflex camera equipped with plate magazines and holders for Lumière Autochrome color plates. My film stock was the standard Eastman motion picture film. My camera plates were Seed Orthonon, in conjunction with which I used Wratten K2 filters as well as with the motion picture film wherever possible. The Akeleys stood up well. For lubrication, I used sparingly Nye's whale oil, such as is used for watch and chronometer lubrication. The Akeleys in the coldest weather—nearly fifty degrees below zero—never froze up. On one occasion, however, during a sledging expedition in January, I mounted the camera, only to find when I began cranking that the film broke up in the gate like so much wafer glass. My pocket thermometer read minus thirty-five degrees. For the balance of that journey my film retorts were kept in an igloo during the night, packed in a grub box, and by day wrapped in my eiderdown sleeping bag, which kept them at a temperature of not more than minus ten degrees, so as to be ready the moment we sighted polar bear, the quarry we were after. With the Graflexes, however, the extreme cold *did* make a difference. From ten degrees on their shutters invariably stuck. If I were to make another similar expedition I should use between-the-lens shutters on them for winter work.

On two previous expeditions while I was exploring in the North, I used a Bell-Howell camera which I purchased in 1913. It was one of Bell-Howell's first cameras—Number 25, to be exact. Though of course it was a better instrument mechanically than the Akeley, I did not like it nearly so well, the Akeley being less bulky. The Akeley shutter too gave me much more latitude in exposure—no small consideration in the North. Another important consideration was the ease of panoraming and above all the ease of loading film in extreme cold—so cold oftentimes that I, all thumbs and running nose, had to call upon Nanook and Harry Lauder, trained into loading and threading the gate at the post, to step into the breach.

My projection outfit worked satisfactorily, though the projection space was nothing larger than the trader's living room and the screen a white Hudson Bay blanket, every square inch of floor being occupied by squatting Eskimos alongside the dynamo and the sputtering, fire-cracking engine which exhausted into the room. But the exhaust had no appreciable effect upon the atmosphere, so pungent was the seal oil odor of the post's best Eskimo society.

Plate and film magazines are to a man in my type of work utterly inadequate. On more than one occasion I have without avail approached the photographic companies with the suggestion that if retorts something like film retorts for motion picture cameras were made for my Graflex cameras sufficient to hold, say, a hundred exposures without loading, they would save endless worry and labor, obviating as they would the loading of half a dozen magazines before striking out from my base and the reloading when they were all exhausted in my changing bag, in the not too comfortable atmosphere of an igloo at the end of a long, tired day; or, worse still, with sweaty hands in the heat-drenched latitudes of Samoa.

It was a far cry from filming the Eskimos to my next venture, Samoa, in the South Seas. Armed with my northern experience and having more latitude in the matter of transportation, my South Sea outfit was more nearly adequate to the kind of film which I proposed to make, which, as "Nanook" was a story of the Eskimo, was to be a story of the Polynesian.

My outfit comprised two Homelite 32-volt generating sets, one to furnish power and illumination for a Power's projector and the other for the Moy printer and motor-driven drying-reels in the laboratory. My developing outfit was a standard studio set of 200-foot developing frames and four wooden tanks for developing, washing, and fixing. The developing and fixing chemicals were Eastman Number 16 developer and Eastman acid hypo fixer. My laboratory was a building a story and a half high, 30 feet long by 20 feet wide, of frame walls, and corrugated iron roof, built under the overspreading branches of a breadfruit tree. It faced the black mouth of a cave which ran down some 30 feet at a steep angle and then wound in for a thousand feet or more under the jungle. The bottom of the cave was covered to a depth of about five feet with water, the coolest, clearest water in all Samoa. Frederick O'Brien had told me all about it before I left New York. It was, in fact, this cave with its cold water which had determined my location in Samoa; namely, the village of Safune, one of the notable villages on the westernmost of the Samoan islands, the island Savaki. More idyllic surroundings for our film work would be difficult to imagine.

Mrs. Flaherty not only collaborated with me on the film, but between us we did the photography. My brother, David T. Flaherty, and L. H. V. Clark, a young New Zealander whom I secured from the government service in Samoa, were our assistants. Clark, I broke in to the developing, printing and laboratory work, which he most ably carried on with the assistance of two unusually bright Samoan boys whose only weakness was the fear of ghosts in the dark-room.

If, however, we thought our film difficulties had ended with the making of "Nanook," we were to be disappointed. In Samoa the difficulty began with the first film tests of native characters whom we proposed to use. The complexion of the Samoans is light reddish-brown. In our tests made with the ordinary orthochromatic film they stood out on the screen as dark as negroes, a lifeless black, so much so that we realized the hopelessness of keeping on unless a color correction could be made. But the problem went even further; for in the greens of the jungle and the water, the deep blue of the sea and the sky, and in the cloud forms, so much a part of Polynesia, this too must be captured. This Polynesian scene, unlike "Nanook" which was a study in black and white and was in all its essentials a dramatic fight for the food wherewith to live, was an idyllic thing, a painter's picture, and all that we had for drama was the inherent beauty of the country and its almost Grecian people. Obviously, there was only one film medium to use and that was panchromatic film. In its use, however, we had had no experience. We soon found that in shadow we could get no correction, particularly in portraiture and the correction of the flesh of our subjects. Only in full sunlight and preferably with K3 filters and open lenses did we secure the complete correction we were after. We shot only in low suns, up to 10 a. m. and after 4 p. m., the sun directly behind us like a low-hanging spotlight flooding the subject. All the close-ups, portraiture, and details were done this way, though the heat on occasions was enough to melt the rubber gaskets on the cameras, and the curtains had to be let down to give our subjects a respite from the sun, or they might have been fried like bacon in a pan.

To us, the method was a revelation not only in the balance of reds and blues and greens, but in the way it brought out through this balance the sculpturesque values of arms and hands and figures, and the forms of trees and leaves as uncorrected orthochromatic film could never hope to do. The transparency of water, as we have shown it in the film, was due of course to the color correction in the green coupled with a staging that enabled me to use the camera high above the water, so that the water itself acted as a reading glass before the camera.

Why, you will probably ask, did we not photograph our portraiture and details with electric illumination? The answer is that we were afraid it would destroy the unconsciousness of our subjects. And if there was one thing in particular that we were after, it was just that quality.

I want to say here that my best results, as I had found with Lumière Autochrome plates, were obtained with open lenses.

A word about the keeping qualities of our panchromatic film in Samoa: Much of the panchromatic film we used was well over the manufacturer's time limit when we used it, but as far as I could see it was satisfactory. The film was shipped down to us from Rochester at three-month intervals. Samoa from Rochester is half way around the world thirteen degrees south of the equator in the South Pacific Ocean.

Now we came to the subject of developing. The cave we converted into a dark-room, bulkheaded the entrance with double doors, and down into the cave over the water, which was about five feet deep, we built a platform. We made inlets in the platform for our tanks, which rested at the bottom of the water, only a foot or so projecting above the platform. The cold water acted as a jacket around them and maintained our solutions at an even temperature. Two electric lights, a table, and rack stands completed the outfit. The temperature of the water, the iciest in all Samoa—and it actually did feel icy compared with the warmth of the air and the sea water, which is constantly 83 degrees—was 76 degrees. All developing was done in complete darkness, tests determining the length of time. With full strength Eastman Number 16 developer, the usual developing time was 2½ minutes. The maximum time as the solution grew weaker was 6 minutes. Fixation was the usual twenty minutes and washing about fifteen minutes. The washing was done by two Samoan boys bailing into a tank which stood close to the water with its outlet of course at the bottom of the tank.

Drying the film proved to be here, as it was during the making of "Nanook," the most difficult of all our operations. Though we had a motor-driven reel and used two oil stoves in attempts at drying the air of the drying-room, on many occasions so excessive was the humidity in Samoa that it required twelve hours to dry our negative. My next equipment will have above all else a drying apparatus designed to *dry* even if the room has to be built in New York and shipped knocked-down to whatever point is to be my destination though that destination may be the farthest corner of the earth.

We found that in the use of the standard studio developing rack our rack flare was particularly excessive, as much as a most marked throb when print or trial pieces of negative were projected. Those parts of the film which were in contact with the top and bottom of the rack were often jet black; sometimes, the density extended a dozen frames or more beyond it. We made endless trials to overcome this rack flare—shuffled the film during development; used tight and loose and moderate windings on the rack; reversed racks while in solution; put racks in water for various intervals before development. We even made a drum and, rotating it, developed in a trough, only to get rack flare on every drum slat upon which the film rested. We got ice from Apia, the metropolis of Samoa, and chilled our solutions to the standard 65 degrees, and that failed. Finally, we sent some of the film to the Famous Players laboratory at Hollywood, where had been installed a refrigeration system which was used to chill the racks. Though less marked than ours, the results they sent back had rack flare. Thereupon I gave up the racks and adopted spirals made by Stineman in Los Angeles. I got them in 200-foot units. We all felt that they would be difficult to handle, load, and discharge, but after a little practice, such we found was not the case. They proved to be most satisfactory. I used wooden trays, however, instead of the monel metal trays which Stineman furnishes. If the spirals could be made of hard rubber instead of metal, I feel that this system would be (outside of developing machines which keep the film in constant movement and maintain even stress) the most perfect developing equipment for my type of work.

We were also troubled by waver—not an uneven waver caused by development, but waver the cause of which it took us a long time to find out. The cause was extraordinary when we did come upon it; it was a tank of stale developer which had been thrown into the cave more than a month before, and though this water in the cave was fed by a spring which bubbled up here and there in its length (which was about a thousand feet) and was constantly discharging (this was proven by the fact that nowhere along the water's edge was there any aquatic growth), the chemicals from the solution remained active, I suppose because the cave was constantly in darkness. How we found that the waver was caused by the decomposition of old developer was by washing our film in other water and getting no trace of waver. The cave water was causing intensification, or, call it what you will, when the film was being washed!

Though we didn't realize it at the time, our experiments did not matter much nor was our final spiral-developed negative—free from waver and rack flare and steady as a rock—so valuable as we imagined. For, in the finished prints of "Moana"—executed in safe and sane and spotless laboratories of the industry—they managed to put back the waver and rack flare that we had taken out plus more pin-holes than I thought the world could hold.

The atmosphere in Samoa is very corrosive. Every metal part of our equipment, nickel-plated or otherwise, if not looked after, soon became a mass of rust. Brass parts became masses of verdigris. A secondhand piano which we had brought with us was in pieces of tin pan in no time; even the sounding board came apart through the softening of the glue. The glue of Graflex plate holders softened, and the holders went to pieces. One of my Graflex 4 x 5 cameras warped so that it was useless. One day I found to my dismay a veining somewhat like the veins in a leaf and an iridescent marking on one of my Dallmeyer telephoto lenses. I found the markings impossible to remove; they were on the inner cells. Those markings are still there, and I am told the lenses will have to be re-ground. But there was just one article we had which, even without care, remained free of corrosion, some English table knives. They were made of rustless steel. If there was one particular source of trouble to me, it was the film track and film gates of my motion picture cameras. Before I go off again, I am going to try to have them made for me out of stainless steel; one of my camera worries and yards of scratched and scarred film will then, I hope, be gone forever.

I often thought while we floundered with our almost overwhelming film outfit in Samoa that if one of our photographic manufacturers had a representative there with us just to study photographic equipment and its practical application under trying and novel conditions, much might be gained thereby, redounding to the prestige of the manufacturer, the infinite comfort (to say the least) of the camera worker, and the advancement of a new field in that which is the common interest of us all—the motion picture.

Discussion

Mr. Crabtree: It is unfortunate that when Mr. Flaherty asked our advice our experiments on rack flare had not progressed sufficiently so that we could assist him in overcoming his difficulty.

With regard to the Stineman developing outfit, it consists of a metal strip wound as a spiral, and the film is wound in contact with it. I agree with Mr. Flaherty that this is a very practical, portable outfit. Certain precautions must be observed in manipulation of the film spiral. If it is agitated vertically, owing to the flow of the developer through the perforations, perforation streaks are obtained. Our experiments have shown that by twisting the rack once a minute, the development is uniform and the perforation marks are eliminated.

With regard to the drying difficulty, I think that if explorers would prevent swelling of the film during development and harden the film in the unswollen condition by following the procedure outlined in the paper on "Handling Motion Picture Film at High Temperatures," (Transactions No. 19), the quantity of moisture to be removed from the film would be reduced to a minimum, and the film would withstand relatively high temperatures during drying. Mr. Flaherty's procedure was to use low temperature air for drying, and naturally film in a swollen condition would dry with difficulty in a humid atmosphere. If he prevented swelling and suitably hardened the film so that air at a higher temperature (and therefore lower relative humidity) could be used for drying, trouble would be eliminated, and it would not be necessary to construct an expensive drying outfit.

LIGHTING BY TUNGSTEN FILAMENT INCANDESCENT ELECTRIC LAMPS FOR MOTION PICTURE PHOTOGRAPHY

E. W. Beggs*

Introduction

THE MANUFACTURERS of tungsten filament lamps are being asked why they are not used to a greater extent for lighting motion picture studios. The idly curious wonder why ordinary stage lighting methods cannot be used and why stage lighting effects cannot be obtained in the "movies." The picture producing engineers want to improve the quality of their pictures and reduce their producing costs and they wish to know if tungsten lamps will help.

At one time tungsten light sources were considered impracticable for photographic work. Today, however, they are standard equipment in many portrait studios and are quite generally used by photographers in portable lighting devices. Also, there are motion picture studios now using nothing but tungsten filament lamps for lighting. Therefore, it is worth while to analyze the problem and determine as nearly as possible the true position of tungsten filament lamps for motion picture photography.

In the theatre and in the movie studio, artificial light is absolutely essential. Without it there would be no vision or no photograph. In the theatre, the light must affect the human eye, but in the studio it must be designed to affect the chemical emulsion on the film. There is this basic difference between the two fields of lighting, and it is because of this that the majority of studios use tungsten lamps to only a very limited extent for the actual illumination of the "movie set," while in the theatre, the tungsten lamp is the standard source of light.

Theatrical lighting has passed through many phases of development. At one time, stages were lighted with candles. We then had the gas flame, the lime light, the arc light, and the carbon filament electric lamp. Now the tungsten lamp is the best source available and is used almost exclusively except for some classes of spotlighting where it has not yet proved its superiority.

* Westinghouse Lamp Co. Bloomfield. N. J.

Characteristics of Tungsten Lamps

The reasons why tungsten lamps have superseded all other types of lamps for theatrical lighting are generally quite well known. The tungsten filament lamps give a light very much like daylight and have all the colors of the spectrum. Their operation is almost as simple as could be conceived, since they are turned on and off by an electric switch and mȧy be gradually dimmed by simply changing the voltage. Having light sources of relatively high concentration, their light flux may be efficiently directed to the point where it is to be used. They have no moving parts and require no attention during operation. They are light and portable. They are clean, do not represent a a fire hazard, and have a long useful life.

Studio Lighting

The history of motion picture studio lighting is comparatively short and is somewhat different from that of the theatre. At first only intense sunlight could be used, but then special types of electric lamps were developed which made motion picture photography practicable indoors. The types of lamps which have been standard for some years are the mercury vapor arc and the open arc between either the plain or cored carbons. These have been quite successful, and without them there would have been little or no motion picture production in studios. However, improvements have been constantly made in the film used and the conditions under which pictures are produced.

Since the motion picture film must depict the scene and the action as it appears to the human eye, it is desirable that it react to the same light intensity and colors. The old film was sensitive to only the light rays of short wave-length, such as the blue, violet, and ultra-violet light. This introduced great difficulties, and so efforts were made to obtain a film which would photograph things as they appear in real life. Orthochromatic film was developed and has now entirely superseded the old type. This film is sensitive not only to the extremely short wave lengths but also to the yellow-green light. Panchromatic, which is sensitive to all the colors of the visible spectrum, is also now available. With it, it is possible to obtain pictures which accurately reproduce the tone values of colòred objects, and all indications point to its use as the standard motion picture film of tomorrow. It has also made possible the production of motion pictures in color, which are becoming increasingly popular.

Photographic Efficiency

In 1915, Mr. L. A. Jones of the Eastman Kodak Co. made extensive tests to determine the relative photographic efficiencies of various types of lamps. Eighteen light sources were tested, and among them were the high intensity open arcs, the open arc between plain carbon electrodes, the mercury vapor inclosed arc, and the tungsten lamp. The first two types of arcs were found to be of approximately equal efficiency and about five times as efficient as the plain carbon arc and the tungsten lamp. Increased sensitivity of the new standard motion picture film and improved intensity of short wave light from tungsten filament lamps resulting from recent improvements have reduced this ratio to approximately four to one in favor of the two special arc lamps. With the new panchromatic film these efficiencies are relatively about the same with the arc lamps, but the light from the tungsten lamp is utilized much more completely. Tests show that with this type of film the wattage required with tungsten light sources to obtain a given photographic effect is about one-half as great as is needed with the present standard orthochromatic film. This explains in part why studios are now generally lighted with the three types of arc lamps; that is, the mercury vapor inclosed arc, the high intensity open arc with special cored carbons, and the open arc with plain carbon electrodes.

Heat Effect

The tungsten lamps are considered by some producing engineers to be impracticable for "movies" for two reasons; first, increased cost of current and lamps; and, second, increased heat generated. If it were not for these two factors and, of course, the existence of present lighting equipment designed for the arc lamps, the situation would be entirely changed. It is, therefore, necessary to analyze the costs and to consider the effect of the radiated heat when a tungsten filament incandescent electric lighting system is proposed to replace the present existing types. To determine the amount of heat generated is a rather simple problem. It is almost directly proportional to the wattage of electrical energy radiated by the various types of light sources. With the tungsten lamp, practically the entire wattage is radiated in the form of light and heat rays. With the arc lamps, this is not the case since approximately 35% of the energy is consumed in the resistances required. Therefore, the total amount of heat radiated to the set itself from the tungsten lamps will be about one-third greater than would be indicated by the relative wattages required by each type of light source for a given photographic effect. For instance, with orthochromatic film the heat from tungsten lamps will be almost six times as great as with either the mercury vapor or the special cored carbon electrode open arc lamps while the picture is actually being taken. However, since the tungsten lamps will be operated at reduced brightness most of the time, the effective heat will be about four times as great.

Direct Cost

It is almost impossible to determine the cost of lighting a studio accurately. This is because the indirect costs which are affected when the type of lighting equipment is changed are often of greater importance than the direct costs. For instance, the effect on the quality of the film or the speed of production would be much more important than the cost of lighting if they would also be largely effected. However, an estimate of the relative direct costs involved in studio lighting with the tungsten lamps and with the arc lamps will be of considerable value.

The direct cost of lighting regardless of the type of equipment used equals the cost of the lamps plus the current, the labor, and overhead. In order to compare the tungsten lamps with the other types, a hypothetical "movie set" will be lighted with each. The conditions will be made as simple as possible in order to avoid confusion.

The approximate data shown below have been calculated for a square floor space 30 feet by 30 feet which is to be uniformly illuminated by each of the three arc lamps and also by the tungsten lamps for a period of 10 working hours. Each type of light source will be considered as being installed in the type of equipment now commonly used for this or other similar applications.

A luminous intensity of 800 foot candles with the tungsten filament lamps will be considered the standard for comparison. It will be assumed that tungsten lamps will be operated at approximately 15 per cent over-voltage during the time when the film is actually exposed. At all other times, these lamps will be operated about 15 percent under-voltage. It will be assumed that this over-voltage operation will be fully compensated for by the under-voltage operation of the lamps thus resulting in a service life approximately equal to that which would be obtained at normal voltage throughout life.

It is also assumed that for the high intensity powerful searchlight lamps, one attendant will be required for each, and for the plain carbon arcs one attendant will be required for five lamps of the 70 ampere type. In the calculations, no consideration of labor will be made for either of the inclosed lamps, that is, the mercury vapor arc or the tungsten filament type.

Approximate figures will be calculated to indicate the relative cost of lighting equipment required for each type of lamp. This will be of interest to the producing engineer, who is in a position to calculate depreciation costs. Of course, these are almost negligible with both the mercury vapor arc and the incandescent tungsten filament lamps.

It will be assumed that the cost of current will be approximately 3 cents per kw. hour, which is a fair average figure for such installations as are being considered.

The "utilization percentages" which are given have been calculated quite accurately from actual data and represent closely enough what is obtained with the types of lighting fixtures and lamps listed. These percentages indicate the proportion of the total lumen output of the light source which is available on the working surface.

CALCULATIONS OF ESTIMATED COSTS

I. *General Overhead Illumination*

A. Using Tungsten Lamps

Conditions:

1. Lamps—1000-watt 115-volt PS52 standard type—$3.75 each.
2. Fixtures—R. L. M. dome, standard industrial reflectors—$10.00 each, including socket (approx.).
3. Lamp life—1000 hours.
4. Light utilized—50%.
5. Light intensity—800 foot candles for orthochromatic film, 400 foot candles for panchromatic film.
6. Lumen output—30,000 (at over-voltage) per lamp.
7. Wattage consumption—800 (at under-voltage) per lamp.
8. Lamp consumption—each lamp burned 10 hours out of 1000 or 1 per cent of life.
9. Current cost—$0.03 per kw. hour.

Computation:

Orthochromatic Film

1. Utilized lumens 800×30×30=720,000 lumens.
2. Generated lumens=720,000÷(utility factor) 50%= 1,440,000 lumens.
3. Number of lamps required=1,440,000÷30,000=48.
4. Cost of lamps=48×$3.75×1%. $ 1.80
5. Cost of current=48×800×10×$.03÷1000= $11.52

operating cost= $13.32

6. Cost of fixtures=48×$10.00 (approx.) $480.00

Panchromatic Film

1. Cost of lamps= $ 0.90
2. Cost of current= 5.76

Operating cost= $ 6.66

3. Cost of fixtures= $240.00

B. Using Mercury Vapor Lamps

Conditions:

1. Lamps—3.5 amperes, 115 volt D. C., 50″ tubes—$15.00 each.
2. Fixtures—standard industrial—$30.00 each without tube.
3. Lamp life—6000 hours.
4. Light utilized—50%.
5. Light intensity—same photic effect as with 800 foot candles under tungsten lamps.
6. Wattage consumption—25% of that with tungsten lamps of same utility factor.
7. Lamp consumption—10 hours out of 6000 or .17 per cent of life.

Computation:

Orthochromatic Film

1. Wattage required=48,000×25%=12,000 watts.
2. Number of lamps required=12,000÷385=31
3. Cost of lamps=31×$15.00×0.17%= $ 0.79
4. Cost of current=12,000×10×$0.03÷1000= 3.60

operating cost= $ 4.39

5 Cost of fixtures=31×$35= $930.00

Panchromatic Film

Costs are approximately the same as when orthochromatic film is used.

II. *"Broadside" Directed Light*

A. Using Tungsten Lamps

Conditions:

1. Lamps—1000 watt 115 volt PS52 standard type—$3.75 each.
2. Fixtures—spun metal parabolic reflectors—approximately $25.00 each
4. Light utilized—35%.
5. Other conditions, same as for overhead illumination, see above.

Computation:

Orthochromatic Film

1.	Generated lumens = 720,000 ÷ 35% = 2,057,140 lumens	
2.	Number of lamps required = 2,057,140 ÷ 30,000 =	69
3.	Cost of lamps = 69 × $3.75 × 1% =	$ 2.58
4.	Cost of current = 69 × 800 × 10 × $0.03 ÷ 1000 =	16.56
	operating cost =	$19.14
5.	Cost of fixtures = 69 × $25.00 =	$1725.00

Panchromatic Film

1.	Cost of lamps =	$ 1.29
2.	Cost of current =	8.28
	operating cost =	$ 9.57
3.	Cost of fixtures =	$863.00

B. Using Plain Carbon Arc Lamps

Conditions:

1. Lamps—70 amperes D. C. arc in theatrical spotlight housings—$50.00 each (approx.).
2. Carbons—$0.10 per lamp per hour.
3. Labor—one attendant for five lamps at $1.00 per hour.
4. Wattage per lamp—8050 watts.

* 5. Light utilized—20%.

* Note: These fixtures are highly inefficient but are quite generally used for this service.

6. Wattage required—approximately same as with tungsten lamps of the same utility.

Computation:

Orthochromatic Film

1. Wattage required = 69,000 × 35% ÷ 20% = 120,750 watts
2. Number of lamps required = 120,750 ÷ 8050 = 15.
3. Cost of lamp operation:—

Carbons = $0.10 × 15 × 10 =	$15.00
Labor $1.00 × 15 × 10 ÷ 5 =	30.00
4. Cost of current = 120,750 × 10 × $.03 ÷ 1000 =	36.23
operating cost =	$81.23
5. Cost of fixtures = 15 × $50.00 =	$750.00

Panchromatic Film

Costs are slightly less throughout than when orthochromatic film is used.

III. *Projected Light*

A. Using Tungsten Lamps

Conditions:

1. Lamps—10,000 watt 115 volt- $175.00 each.
2. Fixtures—36 inch parabolic searchlight mirrors with auxiliary spherical reflectors—$300.00 (approx.).
3. * Lamp life—300 hours (note under-voltage operation)
4. Light utilized—30%.
5. Lumen output at over-voltage—420,000 lumens.
6. Wattage at under-voltage-8,000 watts
7. Lamp consumption—used 10 hours out of 300 or 3.3 per cent of life.

Computation:

Orthochromatic Film

1. Lumens to be generated = 720,000 ÷ 30% = 2,400,000 lumens
2. Number of lamps required = 2,400,000 ÷ 420,000 = 5.7 (6 lamps).

* Note: This figure of 300 hours is only an approximate one, since these lamps have not been available for a sufficient length of time to show what their performance will be. The figure used is probably quite conservative.

3.	Cost of lamps = $175.00 × 6 × 3.3% =	$35.00
4.	Cost of current = 6 × 8000 × 10 × $.03 ÷ 1000 =	14.40
	operating cost	$49.40
5.	Cost of fixtures 6 × $300.00 =	$1800.00

Panchromatic Film

1.	Cost of lamps =	$17.50
2.	Cost of current =	7.20
	operating cost =	$24.70
3.	Cost of fixtures =	$900.00

B. Using High Intensity Arc Lamps

Conditions:

1. Lamps—150 amperes D. C. cored carbon searchlight.
2. Fixture—36 inch standard searchlights-$1000.00 each. (approx.).
3. Lamp operating cost:
   Carbons = $ .50 per lamp per hour.
   Labor = 1.00 " " " "
4. Light utilized—40%.
5. Wattage required—25% of that with tungsten lamps of equal utility.
6. Wattage per lamp—17,250 watts.

Computation:

Orthochromatic Film

1. Wattage required 57,000 × 25% × 40% ÷ 30% = 19,000 watts
2. Number lamps required = 19,000 ÷ 17,250 = 1(plus).
3. Cost of lamp operation:

	Carbons $ .50 × 10 × 1 =	$ 5.00
	Labor = $1.00 × 10 × 1 =	10.00
4.	Cost of current = 17,250 × 10 × $.03 ÷ 1000	5.18
	operating cost	$20.18
5.	Cost of fixtures =	$1000

Panchromatic Film

Costs are slightly less throughout than when orthochromatic film is used.

Summay of Estimated Operating Costs
of
Lighting Systems for the Hypothetical Studio Area

Method of Lighting	*Type of Lamp*	*Type of Film* Orthochromatic	Panchromatic
Overhead	Tungsten	$13.32	$ 6.66
"	Mercury Vapor Arc	4.39	Approximately same as with Ortho.
"Broadside"	Tungsten	19.14	9.57
"	Carbon Arc	81.23	Somewhat less than with Ortho.
Projected	Tungsten	49.40	24.70
"	High Intensity Arc.	20.18	Somewhat less than with Ortho

Analysis of Calculations

An analysis of the figures above which are, as has been mentioned, only approximate, shows immediately that the direct cost with orthochromatic film is lowest with the mercury vapor type of light source used to give a general uniform intensity. If tungsten filament lamps are used to give the same, it will cost somewhat more but will be cheaper than the alternative methods of light herein considered. Next in order come the "broadside" light with Mazda lamps in floodlight reflectors, the high intensity arc searchlight, the tungsten filament high wattage lamps in searchlight projectors, and last the plain carbon open arc lamp in spotlight housings.

Panchromatic Film

With panchromatic film, the order of desirability when direct costs are considered is not changed, but the relative position of the tungsten filament lamp is improved.

Incidentally, the reasons why incandescent tungsten light sources are much more efficient with panchromatic film than orthochromatic film are generally well understood by the producing engineers. However, it might be of interest to explain it briefly here.

If the energy radiated by the tungsten filament electric incandescent lamp were analyzed, it would be found to consist of a continuous spectrum from the ultra-violet to the infra-red. Between these two limits are included all the colors of the visible spectrum:

violet, blue, green, yellow, and red. However, the intensity of the violet and blue is much less than is that of the yellow and the red. Standard orthochromatic film is most sensitive to the blue, violet, and ultra-violet but is acted upon somewhat by the green and yellow light although to a less extent. This means that the red, which represents the greatest proportion of energy from a tungsten lamp, is of no photographic value with orthochromatic film. Panchromatic, however, is sensitive to all colors of the visible spectrum, although its sensitivity also is greatest under the blue, violet, and ultra-violet. However, this is the only commercial film which utilizes the red light, which exists in great quantities in the tungsten light. Therefore, of course, it is the ideal material for use with tungsten lamps.

Color Photography

For color photography and also for black and white pictures where true color-tone reproduction is desired, a colored glass screen or light filter must be used with panchromatic film when exposed to daylight. This filter cuts down the intensity of the light in the blue end of the spectrum, which compensates for the high sensitivity of the film to that light. With the tungsten filament lamp, no such filter is required, since these lamps have their greatest light intensity where the film is least sensitive. This causes an almost exact compensation, and light filters are not recommended for color photography under tungsten filament lamps.

Indirect Cost

The indirect costs which have been mentioned above as being beyond the ability of a lamp engineer to evaluate are rather obvious to those in the motion picture business, but a review of them here would not be out of place. Producing engineers are accustomed to consider them and can, no doubt, estimate their importance. They know how much it is worth to have the actors appear to each other as beautiful or as ugly as they are supposed to be in the scenario. They know how desirable it is to have a light which is steady and of constant color value, such as is a characteristic of the tungsten light. They are often required to arrange for the supply of direct current when only alternating current is generally available and, therefore, know the value of a lamp which operates equally well on alternating or direct current. It costs money to get rid of poisonous fumes or of smoke or dirt produced within a lighting fixture. It is expensive to use materials and lighting equipment which require experts who understand "make up" and the special color combinations required to obtain true color values on the film where none actually exist to the eye. Also it costs money if some of the lighting fixtures must be made up especially for this particular lighting service and perhaps discarded long before they are worn out. Then, too, in photography an accurate measure of all light intensities must be known before the film is exposed. With tungsten light, these intensities are readily measured by standard devices in common use, and the danger of film being destroyed by under or over-exposure is practically eliminated.

The engineer of the studio can appreciate the fact that if his lighting equipment is designed for either black and white pictures or colored pictures but not both he will be constantly handicapped in arranging his sets. A lighting outfit designed to use tungsten filament lamps, of course, will be suitable for either color or black and white pictures. Also, the use of these lamps does not involve any of the other difficulties listed above as indirect costs.

Conclusion

The direct costs of lighting will be seen to be very small and are probably almost negligible compared to other costs involved in picture production. If, therefore, any particular lighting system affects those other very large items of expense, tending to reduce them, it will be highly desirable that studios use such a method of illumination. It is quite probable that the effect of the desirable quality of the light emitted by and the convenient operating characteristics of tungsten filament incandescent electric lamps on the quality and cost of a "movie" production will be appreciable. If so, this rather than the simple cost of lamps, labor, and current will determine if and when they will supersede the other types of available light sources for this service.

DISCUSSION

Mr. Porter: The early 10 kilowatt lamps gave trouble because of the filaments we had to use. They had a heavy coil of wire which gave trouble in shipping, and they sagged in burning, which produced short circuits. This has been overcome by the ribbon filament. One other advantage which Mr. Beggs forgot to bring out is that in recording music with the pictures with some illuminants every time the lamp feeds or on starting there is a record made on the film and the music is affected, but with the steady burning mazda lamps there is no distortion in the music.

Mr. Farnham: Mr. Beggs mentioned an important point in connection with the use of lamps for motion picture photography and one that has received too little consideration in the past, namely, the proper utilization of the light. These lamps are not new in this field, and the lack of equipment especially adapted to the service is largely responsible for their not being more widely used. In general, the reflectors employed have not been satisfactory and to obtain the intensities necessary an excessive wattage was employed. Some experimental work I have conducted with efficient parabolic reflectors shows that much less wattage is required with equipment which gives directional control.

Mr. Palmer: I am not convinced that mazda lamps are now at the stage where we can use them in studios. Arc lamps do make a noise, but they can be burned without making a noise in case talking pictures are being made.

Mr. Beggs: As far as the heat is concerned, there is a tremendous amount in the large wattages required. For an equivalent amount of illumination you need more wattage energy radiated on the object with this lamp than with others, but with a device by which the lamps can be dimmed and operated at low intensity during setting up, there is a great reduction in heating effect. One of the chief objects is to get the set done as quickly as possible, and care is seldom taken to utilize all the wattage in the lamp with carefully designed fixtures.

In the home, of course, the tungsten lamp is ideal for lighting "amateur" sets.

POINTERS ON THEATRE DESIGN AND CONSTRUCTION

H. Robins Burroughs*

THE PROBLEM of building a theatre involves a multitude of factors which are germane to the ultimate results. Consequently, it is important that due and proper consideration be given to the various factors, and especially to those which are of the most importance.

One of these important factors is the type of construction, which involves different kinds of material and their application to the structure as a whole. Theatres in general are constructed in three classes: first, fireproof construction; second, semi-fireproof construction; third, non-fireproof construction. The last, of course, applies to small country towns where frame buildings predominate. The fireproof construction consists of reinforced concrete, structural steel, and masonry work; semi-fireproof construction means that part of the theatre is constructed of the first mentioned materials, and other parts are constructed of wood; the third class of construction involves practically wood. The type of construction which should be used depends on two primary elements: (1) the local building requirements, and (2) the cost of construction. In the average case of fireproof construction, either reinforced concrete or steel may be used, and it is necessary therefore to determine which lends itself most readily to the particular problem in hand, and also which is the most economical.

The matter of economy usually is the outstanding point, so that it becomes a matter of investigation on the part of the designer to determine which kind of material should be used. In general, this is not as simple a matter as it might at first appear to be. For heavy loads where the stresses are in compression re-inforced concrete is recognized as being the most economical. On the other hand, for light loads and tensile stresses, structural steel becomes the most economical. Greater depths should be reached in the analysis however before definite conclusions are arrived at. Many elements need to be considered; for instance, speed of construction, strength, rigidity, fireproofing quality, cost, and probable permanence of the structure.

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In analyzing this subject, general consideration will not suffice for desired results. It will be found necessary to take into account each portion of the structure separately, and, as is generally the case, it will be found certain parts may be efficiently and economically made of reinforced concrete, while other parts of the same structure may be made of steel with equal economy, so that in fireproof construction almost invariably the combination of the two materials is found to work out as being the most satisfactory.

One of the most important points of construction to be considered is that of foundations. Generally there is not much choice on this subject as far as the kind of materials is concerned. Almost invariably it will be found that plain concrete or re-inforced concrete will be the most economical in one form or another unless there be some special condition involving long spans and heavy loads, in which case structural steel may possibly work out to the greatest advantage. On the other hand, concrete, on account of its workability below the ground, lends itself very well to this type of work, so that we may pass on this subject with the decision in the majority of cases invariably in favor of concrete. This does not mean that full consideration should not always be given to a comparison of the two materials; it should, but the results will usually be as stated.

There are two general types of fireproof construction: one which is generally known as the skeleton steel frame type, and the other having self-supporting masonry walls. The best type of construction is to support the structure itself on a steel or re-enforced concrete frame, with the masonry walls self-supporting. This constitutes the usual fireproof construction, so that we have for this class of work a theatre having foundations made of concrete, plain or re-enforced, a structural steel frame supporting building, and masonry walls enclosing the structure and supporting only themselves. All parts of the structure are made of fireproof material and the exposed structural steel is fireproof in one way or another. The roof and balcony floor are also made of concrete as fire resisting material. The walls enclosing the theatre are almost invariably made of brick for the reason that concrete does not lend itself economically to this work; it is very exceptional that concrete can be used economically, due to the fact that these walls are usually high and the problem of placing concrete involves an expensive operation.

A semi-fireproof theatre consists of one that has the same type of construction as the fireproof theatre except that the roof and balcony are usually made of wood. The non-fireproof type, of course, is made practically all of wood, as already stated.

From an operating point of view, the owner or lessee prefers usually a fireproof structure for the reason that his patrons are more secure, and in the event of a short circuit or local fire conditions, the matter becomes one of less alarm. While, as already mentioned, certain parts of the structure may be made of non-fireproof material, the projection booth must always be constructed of fireproof material throughout, as the projection booth is the key to the operation of the theatre.

The projection booth, from the point of view of construction as well as operation, is one of the features in a theatre that frequently does not receive proper consideration. It can easily be seen that the projection room of any theatre plays a major part in its success or failure, and consequently it should receive special attention on the part of the architect or engineer who designs the theatre. Usually there is but one convenient place to locate the projection room, namely, in the rear of the theatre (over the balcony, if there is one) and sufficiently high so that the ray of light will clear all obstacles. In the new Roxy Theatre, New York City, for which the writer has been engaged as consulting engineer, the projection room has been placed in the front of the balcony, which is a departure from the usual practice. This, of course, is an ideal location from a projection point of view and ought to produce as nearly 100 per cent projection as it is possible to obtain. However, the vibration at the front end of the balcony will have to be provided for; there are several ways of doing this, but the writer will not attempt to go into them at this time.

Another good location for the projection room in a comparatively small theatre is, of course, above the balcony if there is one but outside of the main theatre wall, so that in case of fire the projection room is entirely independent of the theatre proper. This construction is usually obtainable where there are stores and offices on the street front and the theatre proper is set back, so that the projection room can be placed over the office portion of the building but, of course, independent of it.

The modern projection room in a theatre of any considerable size requires in addition to the main room, a grid room, a workshop, and toilet facilities, all of which should be provided for. Also, proper means of exit should be provided for the operators in case of fire.

Frequently the entrance and exit to the projection booth is by an indirect circuitous route, possibly through the attic of the theatre or by means of a walk-way above the suspended ceiling. In such cases, in case of fire those in the projection room would be hopelessly caught with no means of escape should the fire happen to spread to that portion of the building.

Too frequently insufficient study and consideration are given to the projection room. The comforts and convenience of the operators are overlooked, and the projection room is either too small or improperly located. In certain instances the writer has known where the projection room has been so badly located that when putting in the machines interference was found between the machine and the screen, which necessitated considerable alteration in order to clear the picture. This is due, of course, to little or no thought having been given to clearance lines from the projection booth.

From this it can readily be seen that the architect or engineer who lays out a theatre should give careful and thorough consideration to the projection room; its location and layout—as engineers who operate the projection of motion pictures as well as lighting effects and other points of control which come under their jurisdiction are obliged to remain constantly on the job and should therefore be given every consideration when the theatre is laid out. The operation of the theatre of today is primarily under control from the projection room, which is, of course, under the direction of the management, and the operators there are acting as engineers second in command only to the manager of the theatre, and it behooves the management of any theatre to obtain efficient and reliable men to handle the projection and other allied features. In other words, a theatre is actually operated from the projection room under the direction of the manager.

In conclusion, the writer wishes to emphasize the importance in building a theatre of first obtaining the services of a competent engineer or architect who is thoroughly alive to the requirements of an up-to-date theatre from the operator's point of view. The designer should always keep in mind the completed theatre and its operation and second, see that the building is properly constructed and has an adequate factor of safety.

INVESTIGATIONS ON PHOTOGRAPHIC DEVELOPERS

Part III

The Effect of Desensitizers in Development

M. L. Dundon and J. I. Crabtree*

I. Introduction

THE INSPECTION of film during development is often desirable even though the time and temperature method can be used to produce negatives of a definite development contrast or gamma. Especially in the case of motion picture film, where only one positive material is used for printing all scenes, the production of negatives of fixed density contrast is desirable. In order to obtain this result, the time of development must be varied according to the contrast of the original subject. Also, in ordinary photography, freedom of inspection during development may be of great assistance in obtaining the particular results desired.

II. Methods of Securing Maximum Visibility during Development

The greatest possible visibility during development may be obtained by using an efficient safelight and by desensitizing the film.

A. Suitable Choice of Safelight

In selecting an efficient safelight there are two factors to consider: (1) the sensitivity of the eye to light of different colors or wavelength and (2) the color sensitiveness of the emulsion used. Mees and Baker[1] have explained this matter clearly and defined safelight efficiency as the product of the visual intensity of the light transmitted multiplied by its safety for a given emulsion. The relation of these factors is represented graphically in Fig. 1, where curves showing the spectral sensitivity of the eye and the spectral sensitivity of typical photographic emulsions are plotted on the same scale of wave-lengths as the transmission of the Wratten

* Communication No. 270 from the Research Laboratory of the Eastman Kodak Co.

[1] C. E. K. Mees and J. K. Baker, "A Measurement of the Efficiency of Dark Room Filters," Phot. Jour., *47*, 267, (1907).

safelights. From the upper curve[2] showing the spectral sensitivity of the eye, it is evident that for a given intensity of radiation, the human eye is much more sensitive to green or yellow than it is to red or blue light. In fact, the average point of maximum visibility for a large number of observers was at 560 mμ.

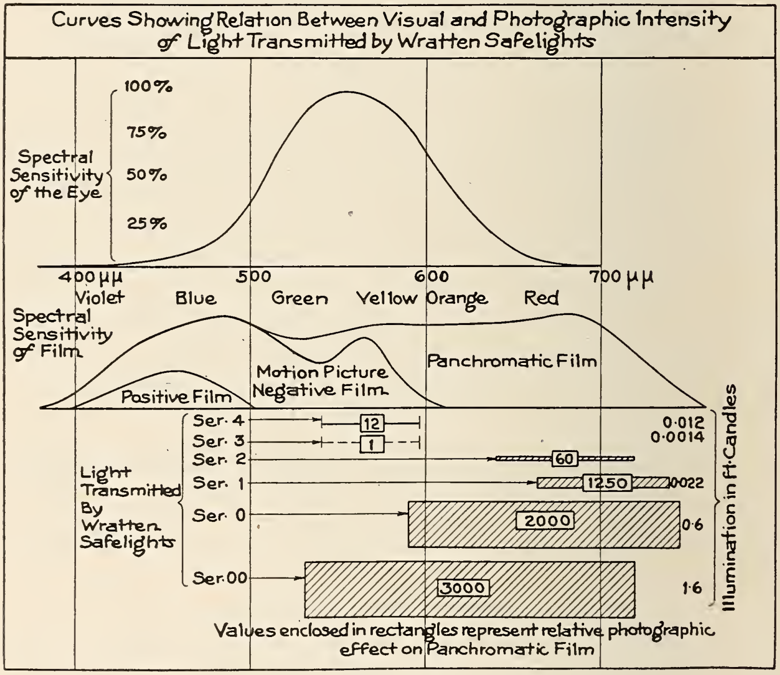

FIG. 1.

Ordinary photographic emulsions, on the other hand, are sensitive to only the blue and violet, but when made orthochromatic they are sensitive also to green, and when panchromatic the sensitivity includes the red and is extended throughout the visible spectrum. The light transmitted by the Wratten Safelight filters is represented in this diagram by blocks of which the extent of the base line corresponds to the wave-lengths transmitted. The area and the accompanying number represent the relative photographic effectiveness of the light. This was measured by the effect produced

[2] K. S. Gibson and E. P. T. Tyndall, "Visibility of Radiant Energy," Sci. Paper, Bur. Standards, No. 475.

on a panchromatic film when exposed to the different safelights for the same time through a step tablet (See Fig. 2). At the right are the values in foot candles for the illumination given by the safelights and measured at a distance of 1 foot (30 cm.) when used in a Wratten safelight lamp containing a 25-watt bulb. The measure-

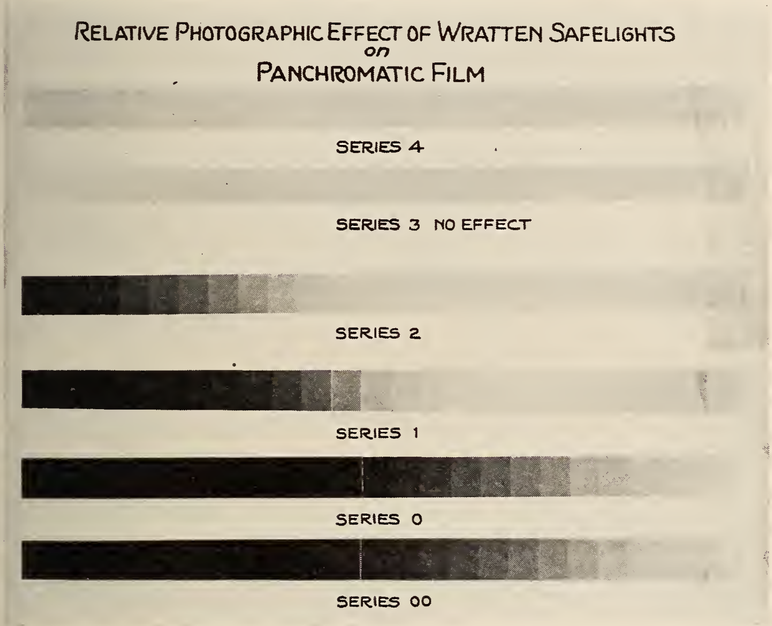

FIG. 2.

ments were made with a Macbeth illuminometer. From this diagram it is evident that the yellowish green safelight, Series 3, is the most efficient for panchromatic materials, while for emulsions which are not red sensitive the red safelights Series 1 or 2 are better because of the relative insensitivity of the film to the light which they transmit. The extent to which these relations are modified by the use of desensitizers in development will be indicated later.

In Fig. 2 is shown the method by which the relative photographic effect of the light transmitted by the different safelights was measured. A step tablet having a density range of 3 4 was placed over a sheet of Commercial Panchromatic film. Narrow strips were then exposed to each of the different safelights for the same time and in the same manner, and the whole sheet developed. From the densities of the step tablet corresponding in each case to the first visible image, the relative exposures were calculated.

The limits of safety in exposing Eastman Motion Picture Negative and Commercial Panchromatic film to the various safelights is shown in Table I. The fog density produced with normal development by a ten seconds' exposure to the safelight at a distance of one foot is given except where no effect was obtained in this time. In such cases the time required to produce a visible fog is recorded.

Table I.

Exposure at 30 cm. (1 ft.) from 8″ × 10″ Wratten Safelight Lamp Containing 25-watt Bulb

Safelight	*Relative Fog Density Produced by 10 seconds Exposure*	
	Panchromatic Film	*Motion Picture Negative Film*
Series 00	2.2	1.9
" 0	2.0	1.2
" 1	1.5	Fog in 1 minute
" 2	1.5	Fog in 2 minutes
" 3	0.2	Fog in 15 seconds
" 4	1.0	0.8

From Table I, it is evident that sufficient light cannot be used with panchromatic film without desensitizing to inspect it satisfactorily during development, even though the sensitivity may be slightly decreased when wet with developer. Motion picture negative film, on the other hand, can be inspected quite freely with a red light such as is given by the Series 1 safelight.

B. *Desensitizing*

1. *Purpose of a Desensitizer*

A photographic desensitizer is a substance which has the property of greatly diminishing the sensitivity of a photographic emulsion toward light action. To be of practical use in development it must not affect a latent image already present nor interfere with its subsequent development.

The most important reasons for using a desensitizer are: (a) to permit the inspection of panchromatic film during development, (b) to give much greater freedom in the use of safelights during the development of ordinary film, and (c) to prevent aerial or oxidation fog.

In a previous communication[3] it has been shown that the presence of a desensitizer in a concentration of 1/500,000 or even 1/1,000,000 in a developer which has a tendency to produce aerial fog is sufficient to prevent such fogging action. This is of considerable value in the machine development of motion picture film, and for such use it has been found possible, by adding one part in a hundred thousand of phenosafranine, to use a dilute elon-hydroquinone developer with much less sulphite than would otherwise be necessary.

It has been stated in the literature[4] that in some cases a desensitizer also diminishes ordinary development or tank fog. This effect may be a decreased oxidation fog within the developer, but with certain developers tank fog is apparently diminished. This is discussed more fully in another section.

In the present paper it is proposed to show the extent to which the use of a typical desensitizer will permit greater safelight illumination during development.

2. Methods of Use

Desensitizing dyes are used either as a preliminary bath or in the developer itself. As a preliminary bath a concentration of 1/5000 or 1/10,000 is commonly used, and the film is dipped in the desensitizing solution for one or two minutes just previous to development. This operation must, of course, be carried out with proper safelights or in the dark.

When used in the developer, the concentration usually recommended is 1/25,000 or less, and the film is left in the developer for one or two minutes before exposing it to a safelight stronger than usual. In most cases the same concentration of dye desensitizes much more powerfully in the developer than in a separate water solution.[5]

3. Considerations in Selecting a Desensitizer

Many dyes and other substances are known which greatly reduce the sensitivity of emulsions. However, in finding a substance

[3] Merle L. Dundon and J. I. Crabtree, "Investigations on Photographic Developers, II. The Fogging Properties of Developers," Amer. Phot., *18*, 742, (1924); Rev. Franc. Phot., *5*, 320, (1924); Sci. Ind. Phot., *5*, 1, (1925), B. J. Phot., *71*, 701, 719, (1924).

[4] A. E. Amor, "The Prevention of Tank Fog," B. J. Phot., *72*, 183, (1925)

[5] A. Hubl, "Contributions to Development in Bright Light," Phot. Rund., *62*, 114, (1925).

suitable for practical use there are many factors involved, the most important of which will be considered briefly.

(a) *Desensitizing Power*

Desensitizing power is, of course, the first consideration. With desensitizers now known the speed of an ordinary fast emulsion to white light can be reduced several hundred times, while the decrease in sensitivity of panchromatic emulsions to certain safelights may reach several thousand times. Different desensitizers vary considerably in their ability to decrease the relative color sensitivity of panchromatic materials, and this variation also depends on the particular dyes used to give color sensitiveness to the emulsion.

(b) *Effect on the Latent Image*

To be of practical use a desensitizer must not remove to any extent a latent image already present on a film within a reasonable length of time. Most desensitizing dyes will destroy a latent image if the desensitized film is exposed to strong red light, and Carroll[6] has reported that even in the dark pinakryptol green will destroy a latent light image if allowed to stand several hours before development. This fact has been confirmed in this investigation.

(c) *Effect on Development*

Desensitizing dyes generally decrease the induction period of certain developing agents such as hydroquinone and pyro and so may change the Watkins factor of a developer. Some desensitizers retard development. It is, of course, desirable that the addition of a desensitizer will not affect the time of development nor change the shape of the characteristic curve of the developed image.

(d) *Fogging Action*

Some of the most powerful desensitizing substances known, such as methylene blue, have an independent fogging action which entirely prevents their use for this purpose. No appreciable fogging action can be tolerated, although certain commercial desensitizers have a slight tendency in this direction.

(e) *Staining Action*

Some of the desensitizers in use stain not only the gelatin of the film and the trays in a very disagreeable manner but also the

[6] B. H. Carroll, "Solarization and Photographic Reversal by Desensitizers," J. Phys. Chem., *29*, 693, (1925).

fingers of the person who uses them. The stain is most persistent in the hardened gelatin on the back of a non-curling film. A desensitizer which does not stain gelatin or which washes out very easily is desirable.

The color or absorption region of the stain produced is also of importance, because if it does not transmit blue light the printing time of a stained negative may be affected.

(f) *Color in Relation to Safelight*

If desensitized films are to be inspected by transmitted light during development, the color of the desensitizer with which a film is stained must be such that it does not absorb the light transmitted by the safelight. Otherwise the whole film will appear fogged or too dense to examine satisfactorily. For instance, phenosafranine appears black in a green light and colorless in a red light.

(g) *Solubility in a Developer*

The concentration in which desensitizers can be added to a developer is often limited by the fact that they form an insoluble precipitate with certain developing agents, especially hydroquinone. In extreme cases a precipitate may form in an emulsion when it is put into a developer after a preliminary desensitizing bath.

(h) *Stability*

Some desensitizers which are very effective as a preliminary bath are destroyed immediately by the sulphite if added to a developer. The stability in a developer and the keeping property of the water solution when exposed to light and air are important factors.

(i) *Speed of Action*

Especially when a desensitizer is used in a developer, the speed of the desensitization is important. Luppo-Cramer[7] has pointed out that while Rhoduline Red G is as strong a desensitizer as phenosafranine, it takes twice as long to produce the same effect. This is probably due to a slower rate of diffusion through the gelatin.

(j) *Availability and Cost*

For general use it is obvious that a substance must be available at a reasonable price.

[7] Luppo-Cramer, "Protective Dyes in Desensitizing," Phot. Ind., 187, (1925)

III. Comparative Properties of Different Commercial Desensitizers

A. *Phenosafranine*

The first important member of this series is phenosafranine, of which the desensitizing action was discovered by Luppo-Cramer and is described fully in his book on the safranine process.[8]

Many of the safranine dyes have a similar desensitizing action, but considering all its properties Luppo-Cramer considered phenosafranine to be the most generally useful of those which he examined. Phenosafranine has a strong desensitizing action, does not give trouble from fog, and is a well known and easily obtainable substance. It is perfectly transparent in a bright red light but has a dark appearance in a green light. It is less effective in desensitizing panchromatic materials, such as Eastman Commercial Panchromatic film, than is pinakryptol green. When used with an ordinary plate suchas Eastman 40, it extends the spectral sensitivity through the green, giving a maximum at 580 mμ. Phenosafranine forms a precipitate in developers containing hydroquinone to about the same extent as does pinakryptol green but if added with care can be used in most elon-hydroquinone developers. In pyro developers it is distinctly less soluble than is pinakryptol green.

The most serious objection to the use of phenosafranine is the intense stain which it imparts to the film, trays, and hands. When a film is thoroughly fixed in an acid fixing bath, most of the dye washes out quite readily. However, any residual stain left in a negative has no effect on its printing time as phenosafranine transmits the violet light to which positive emulsions are most sensitive. When used in small concentrations to prevent aerial fog its staining action is not appreciable.

In Fig. 3 is shown the absorption spectrum of phenosafranine in relation to that of pinakryptol green and basic scarlet N.

B. *Pinasafrol*

Pinasafrol is stated by Wall[9] to be safranine J IV or tetra methyl safranine. It is said to be a slightly stronger desensitizer[8,10,11]

[8] Luppo-Cramer, "Negative Development by Bright Light, The Safranine Process," 2nd Edition, Leipzig, 1922.

[9] E. J. Wall, "History of Three Color Photography," Boston, 1925, p. 300. This book also contains a very complete bibliography on desensitizing.

[10] Luppo-Cramer, "The Best Desensitizer," Phot. Ind., 1356, (1925).

[11] Stammreich and Thuring, Zeit. wiss. Phot., *23*, 363, (1925).

than phenosafranine but was stated by Luppo-Cramer to be less desirable for practical use because it is not transparent in a red safelight. It has not been tested in this laboratory.

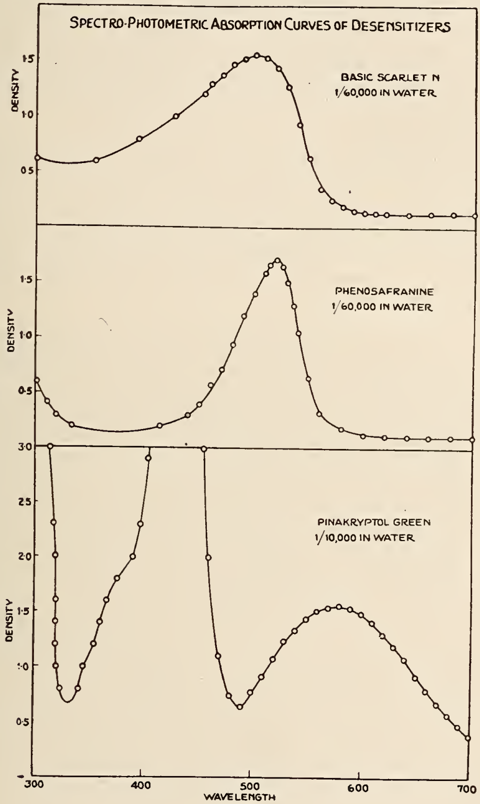

FIG. 3.

C. *Pinakryptol Green*

Pinakryptol green has about the same general desensitizing power as phenosafranine but is more effective with panchromatic emulsions. It has no effect on the latent image when used immediately before or during development and does not affect the keeping properties of a developer. It has a slight but distinct fogging action, however, and if used for too long a time or in too high a concentration as a preliminary bath undesirable fog may be produced. As ordinarily used, this is not serious. The chief advantage of pinakryptol green is the fact that it does not tend to stain gelatin and so washes out of the emulsions very easily. It is colorless in a yellowish green light and so can be used very advantageously to develop panchromatic films with the Series 4 Wratten safelight. The tendency to form a precipitate with hydroquinone in alkaline solutions limits the concentration that can be added to a strong hydroquinone developer, but with ordinary elon-hydroquinone or pyro developers it can be used satisfactorily.

Pinakryptol green is much more expensive than phenosafranine at the present time. Its composition has not been published, although the general structure of the class of dyes to which it probably belongs was recently described by Homolka.[12]

D. *Pinakryptol Yellow*

Pinakryptol yellow desensitizes more powerfully than pinakryptol green in the same concentration and can be used much more strongly because of its colorless, non-staining solution. Also, it is much more active in destroying the color sensitivity of a panchromatic emulsion. When tested with Eastman Commercial Panchromatic film and an elon-hydroquinone tank developer, it was found to have no effect on the latent image or its subsequent development. It cannot be added to a developer, however, as it is destroyed by sulphite, and some other desensitizer must be used in the developer to prevent the film from regaining its sensitivity during development. A solution of pinakryptol yellow is also said to be slowly decomposed by exposure to light.[13] It differs from other common desensitizers in that it greatly retards the direct photochemical blackening of an emulsion such as developing paper. As a preliminary bath for desensitizing panchromatic film, it is the most effective of all the desensitizers considered in this investigation.

E. *Pinakryptol*

Pinakryptol, which was on the market before pinakryptol green, consists, according to Luppo-Cramer,[14] of a mixture of pinakryptol yellow and pinakryptol green.

[12] B. Homolka, "New Desensitizing Dyes," Phot. Ind., 1925, p. 347.

[13] A. Hubl, "Contribution to the Knowledge of Desensitizers," Phot. Rund., *62*, 71, (1925).

[14] Luppo-Cramer, "The Origin of Pinakryptol Green and Other Dyes," Phot. Ind. 1924, p. 1194.

F. *Basic Scarlet N*

Basic Scarlet N was proposed as an effective desensitizer by the Laboratory of Pathé Cinema.[15] It is apparently a mixture of safranine and auramine.[16] Hubl[17] states that it is less effective in desensitizing panchromatic emulsions than pinakryptol green and that its desensitizing power in a developer is no greater than in water solution. Tests in this laboratory have shown that it offers no advantage over phenosafranine in desensitizing power, that it is no more soluble in hydroquinone or pyro developers, and that the persistency of the stain is about the same. As is indicated by its absorption spectra, Fig. 3, its stain has a greater tendency to retard printing than phenosafranine stain, but in the amount present in an ordinary fixed and washed negative such an effect is inappreciable.

G. *Aurantia*

Aurantia has been recommended by Lumière and Seyewetz[18] especially for use with Autochrome plates. Its desensitizing power is far less than that of phenosafranine, it stains badly, and washes out slowly. Unlike most other desensitizers it can be added to a concentrated strongly alkaline hydroquinone developer in a concentration as much as 1/500 without precipitating and for this reason may have some use in special cases.

H. *Miscellaneous Dyes*

A large number of dyes are known[18,19,20] which desensitize photographic emulsions but which are not practically useful because they produce some undesirable effect, such as fog, stain, destruction of the latent image, or retardation of development. Notable among such substances is methylene blue, which is a more powerful desen-

[15] Research Laboratory of Pathé Cinema, "New Desensitizers," Le Phot., 11, 296, (1924).

[16] Lumière and Seyewetz, "Constitution of Desensitizing Azine Dyes," B. J. Phot. *72*, 446, (1925).

[17] A. Hubl, "Basic Scarlet N as a Desensitizer," Phot. Ind., 1925, p. 432.

[18] A. and L. Lumière and A. Seyewetz, "Experiments on Desensitizers," B. J. Phot. *68*, 351 and 370, (1921).

[19] E. Stenger and Hans Stammreich, "Contribution to the Knowledge of Desensitizing Silver Bromide-Gelatin Emulsion," Zeit. wiss. Phot. *23*, 11, (1924).

[20] J. G. F. Druce, "Notes on the Action of Desensitizers in Photographic Development," Science News, Nov. 1924, p. 2.

sitizer than pinakryptol green but which fogs[21] very badly. It has been stated[15] that methylene blue can be used in connection with another dye such as acridine yellow, which retards the fogging action and still permits desensitizing. Other combinations suggested are rhoduline blue or rhoduline violet with acridine yellow. The methylene blue-acridine yellow mixture was tested and found to desensitize well without serious fog when carefully used. However, it has no advantage over other common desensitizers, as Luppo-Cramer[7] has also shown, and a mixture is certainly less desirable than a homogenous substance.

Reasons for Investigating the Action of Pinakryptol Green

Pinakryptol green was selected for studying the limits of safety in the use of a typical desensitizer, because it appeared to be the most satisfactory in all respects of any desensitizer available at the time of this investigation.

IV. Methods Used for Testing Desensitizing Action

A. *Tablet Exposures*

A step tablet was prepared which had 25 steps covering a density range from 0.14 to 3.40. Over this were placed narrow strips of the dyed gelatin filters corresponding to the Wratten safelights Series 00, 0, 1, 2, and 3. The strip on which white light measurements were made was covered with a neutral density of 2.30 in order to bring the exposures within the same range as those through the safelight filters.

Tests were made by soaking a strip of film in the solution to be tested, removing excess liquid by drawing it quickly across a piece of chamois stretched over a bottle, and exposing while wet through the tablet. Exposures were made in a cabinet lined with black cloth 50 cm. from a 200 W. tungsten lamp which had a candle power of 176 as used. Exposures for desensitized film were 5 minutes and for untreated film, 10 seconds. The strips were developed for 10 minutes in an elon-hydroquinone tank developer[22] (MQ-80 tank), fixed, and washed. From the last visible step on each strip, relative exposure values necessary to produce a visible density were calculated.

[21] J. Eggert and J. Reitstotter, "The Photographic Effect of Methylene Blue as an Adsorption Effect," Kolloid Zeit., 36, 298, (1925).

[22] J. I. Crabtree, "The Development of Motion Picture Film by the Reel and Tank System," Trans. Soc. M. P. Eng., *16*, 163, (1923).

Comparison with the value for untreated film showed the relative sensitiveness for each treatment. With one exposure through the tablet, values could be obtained for white light and for each of the safelights mentioned above. By this method the measurements were made on an intensity scale instead of a time scale. The values obtained were subject to an error at least equal to the difference in exposure represented by one step on the tablet, which would be about 50%. Considering the enormous range in sensitivity covered, a difference of 100% would not be serious, however, as this would only mean that a film might have, for example, either 0.1% or 0.2% of its original speed. For practical use a margin of safety much greater than this should be allowed.

B. *Direct Exposure to Safelights*

In order to relate the results of the tablet exposures to practical darkroom conditions, the time required to fog desensitized film when exposed directly to the safelights was determined. Strips of film 10 cm.×25cm. (4″×10″) were dipped by stages into a desensitizing bath so that the different areas were in the solution 5, 3, 2, 1, and ½ minutes with an untreated portion left on the end. The strip was then wiped with a chamois, placed under the safelight to be tested, and an opaque slide moved across it in such a way that each of the above areas were exposed 8, 4, 2, 1, and ½ minutes. The exposure was made at a distance of 30 cm. (1 ft.) from a Wratten Safelight lamp fitted with a 25 W. bulb. The values for the illumination in foot candles afforded by the different safelights under these conditions are given in Fig. 1. From these strips after development, the longest time of exposure which did not cause visible fog for each time of bathing could be determined.

C. *Exhaustion Tests*

For the keeping and exhaustion tests solutions were kept in 2 liter glass battery jars which were deep and narrow and simulated the conditions in a large tank.

V. The Use of Pinakryptol Green as a Preliminary Bath for Desensitizing Motion Picture Negative and Panchromatic Film

A. *Effect of Concentration and Time of Bathing on Desensitizing*

Various authors[19] have considered the relation between concentration and desensitizing. As Hubl[13, 23] has suggested, it appears

[23] A. Hubl, "A Contribution to the Knowledge of Development in Bright Light" Phot. Rund. *62*, 235, (1925).

that the amount of desensitizing substance which enters the film layer is the determining factor. Desensitizing is very nearly proportional to the concentration of the desensitizing solution; it increases with rise of temperature and is diminished by anything which retards swelling such as previously hardening with alum. The temperature coefficient of desensitizing varies with the particular dye used.

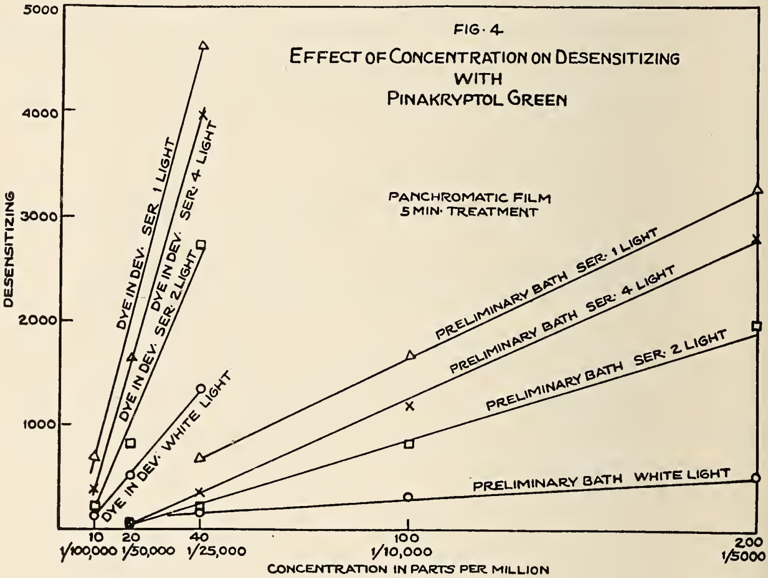

Fig. 4.

The desensitizing action of pinakryptol green was measured for various concentrations and times of bathing by the tablet method described above. The results for panchromatic film are given in Fig. 4, in which desensitizing is plotted against concentration of the dye. Desensitizing is stated numerically as the ratio of the original to the final speed. For these tests the time of the preliminary bath was 5 minutes. The results show that within the range studied desensitizing is directly proportional to the concentration. The curves for the different safelights have no relation to each other in the sense of absolute safety, but each represents the increased safety due to desensitizing for that particular light. In Fig. 5 are shown similar results for motion picture negative film with 2 minutes' bathing.

The effect of pinakryptol green on the relative color sensitivity of panchromatic film is shown by Fig. 6. Pieces of panchromatic and motion picture negative film were bathed for 2 minutes in pinakryptol green 1/10,000, dried and exposed in a spectrograph. The desensitized samples were given about 200 times as much exposure

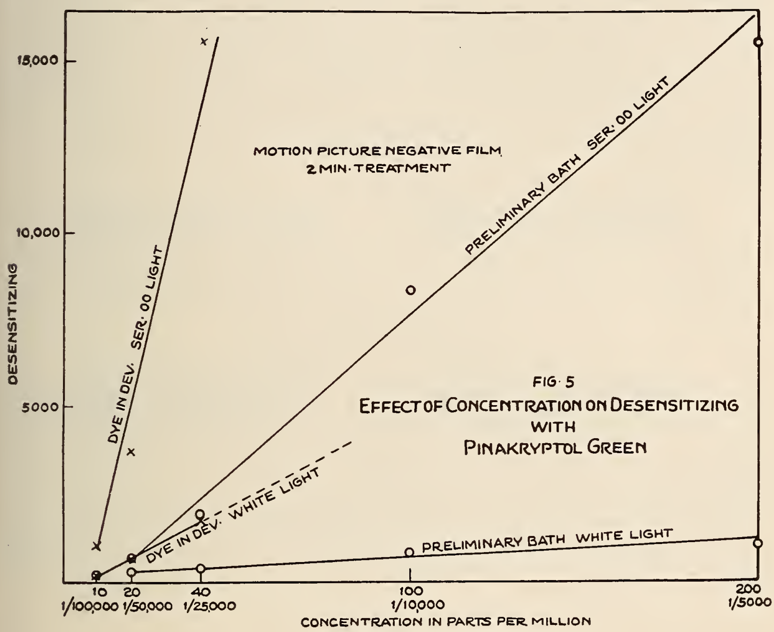

Fig. 5.

as the untreated film. It is evident that desensitizing with pinakryptol green reduces color sensitivity much more than it does the original blue sensitivity of the emulsion. The effect of different dyes in this respect varies greatly. Pinakryptol yellow is more effective than pinakryptol green in reducing color sensitivity and phenosafranine less so. In fact, phenosafranine is actually a color sensitizer to a slight degree and confers a definite color sensitivity on ordinary plates with a maximum effect at 580 $m\mu$ in the green-yellow region. Basic scarlet N also extends slightly the sensitivity in the green.

The effect of time of bathing on sensitivity may be seen from typical curves of Fig. 7, in which sensitivity of panchromatic film is plotted against time of bathing. It is evident that sensitivity falls off very rapidly for the first minute or two but diminishes very slowly after 5 minutes.

B. *Limits of Safety in Exposing Desensitized Film to Different Safelights*

In Table I, the comparative safety of untreated film to safelight exposures was indicated. In Table II, are given similar data for film desensitized for 2 minutes and 5 minutes with various concentrations of pinakryptol green. The numbers represent time in minutes for which exposures were made without producing visible fog. Tests were only extended to 8 minutes, as it was considered that this was sufficient time of exposure to cover any practical need, although in many cases the time of safety was much longer.

Table II

Safe Time of Exposure of Desensitized Film to Wratten Safelights

Exposures at 30 cm. (1 ft.) from 8″×10″ Wratten Safelight Lamp containing 25 W. Bulb

Panchromatic Film

	Concentration of Preliminary Bath								*Concentration of Dye in MQ Tank Developer*			
Wratten	1/5000		1/10,000		1/25,000		1/50,000		1/25,000		1/100,000	
Safelight Series	2 *min*	5 *min*	2 *min*	5 *min*	2 *min*	5 *min*	2 *min*	5 *min*	2 *min*	5 *min*	2 *min*	5 *min*
1	F	F							F		F	F
2	1	2										
3	>8	>8	>8	>8	>8	>8	1	8	8	8		
4	>8	>8	>8	>8	1	8		1	8	8	F	1

Motion Picture Negative Film

00	1	8	F	½	F	F	F	F	8	>8	F	F
0	>8	>8	>8	>8	>8	8	1	8	>8	>8	1	8
4	>8	>8	>8	>8	>8	8	4	8	>8	>8	8	8

F indicates fog in less than ½ minute, and the numbers show the time in minutes for which the film could be exposed without visible fog after a treatment corresponding to the time and concentration given at the top of the column.

From these figures, it is seen that by bathing panchromatic film in a 1/10,000 solution of pinakryptol green or after the film has been in the developer containing 1 part in 25,000 of the desensitizer, inspection of the film may be conducted with safety with a Series 4 Wratten safelight containing a 25 watt bulb at a distance of 12 inches.

Under the same conditions motion picture negative film may be safely examined with a Series 0 safelight.

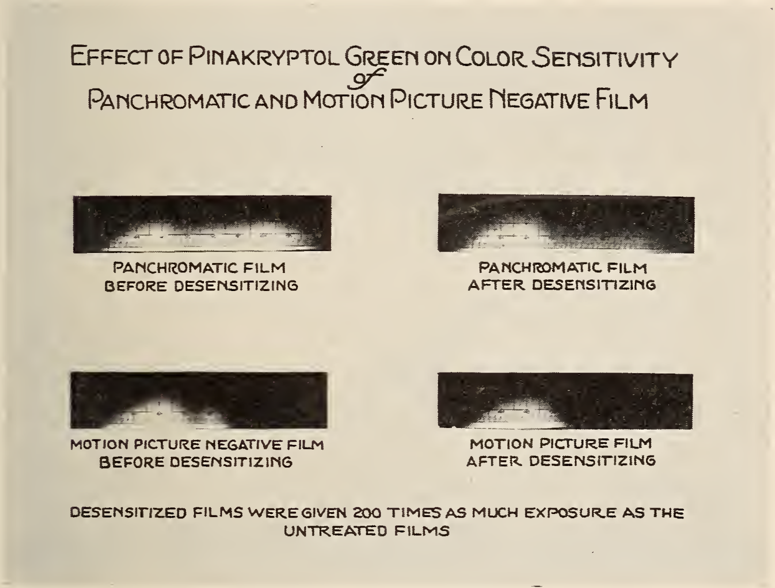

FIG. 6.

C. *Bleaching of the Latent Image on Desensitized Film by Red Light*

It is a well known fact that when an exposed plate is treated with certain dyes and then exposed to red light, the latent image of the first exposure is destroyed. Ordinary desensitizing dyes promote this action very strongly. In fact, as Luppo-Cramer[24] has shown, if a plate is given a uniform exposure, bathed in phenosafranine, exposed through a negative to red light and then developed, the preliminary exposure is removed in such a way that a duplicate of the negative is produced. In the case of an iodized

[24] Luppo-Cramer, "Desensitizing and Duplicate Negatives," B. J. Phot. *69*, 765, (1922) (Abs.) Phot. Rund, *59*, 269, (1922).

plate when treated with certain dyes bleaching may take place even in blue light.[25]

In the ordinary practice of developing a desensitized film in bright red light, this bleaching action may be quite serious. With

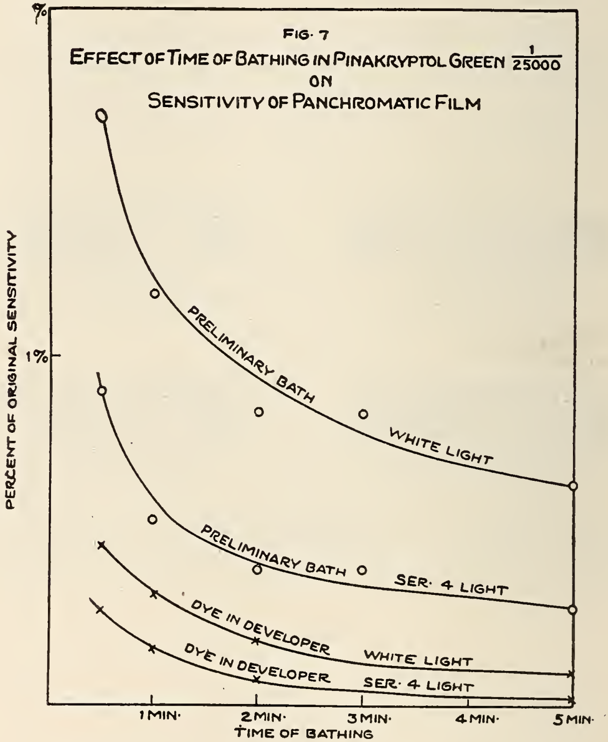

FIG. 7.

a non-color sensitive film after a preliminary desensitizing bath but before development, the safe time of exposure to a red safelight is not measured by the time required to produce fog but by the time required to destroy the latent image. With panchromatic film the red sensitivity is not destroyed sufficiently for bleaching to become serious. Also, after development has once started no appreciable bleaching occurs. With motion picture negative film, bleaching has been found to take place with Wratten safelights

[25] Luppo-Cramer, "Bleached Out Pictures in Silver Iodide," Phot. Ind. 1925, p. 650.

Series 0, 1, and 2, and with positive film even Series 00 was effective. No bleaching has been detected with the green safelight, Ser. 4.

In Fig. 8 is shown the bleaching effect of red light on a latent image with motion picture negative film. A step tablet exposure

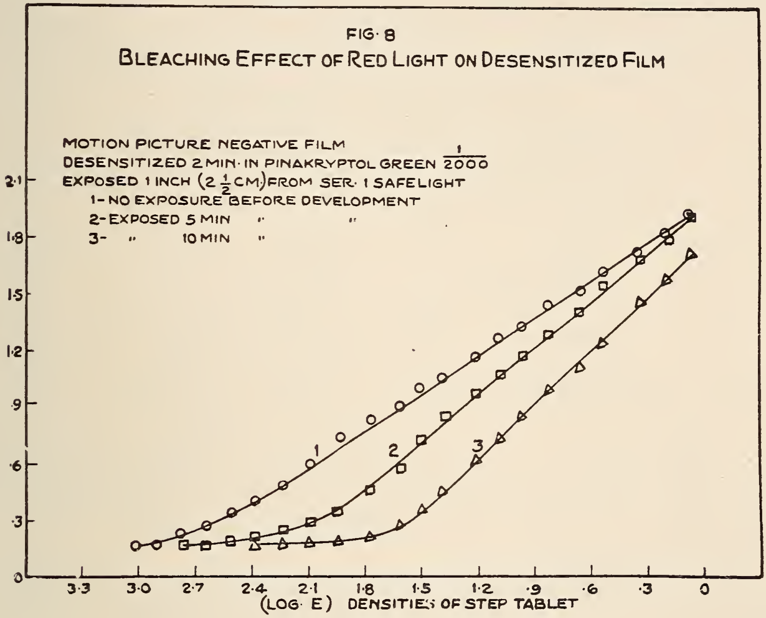

FIG. 8.

was made, the film bathed in pinakryptol green 1/2000 for 2 minutes, parts of the sheet exposed to a Series 1 safelight at 1 inch for 5 and 10 minutes, and the several parts of the sheet developed together. The progressive destruction of the lower densities and resulting increase in contrast is evident. Of course these conditions are much more severe than would occur in practice.

In Table III, the results of another interesting experiment are tabulated. A sheet of motion picture negative film was given a flash exposure sufficient to develop to a density of about 0.90. It was then cut into strips which were desensitized for 5 minutes in solutions of pinakryptol green of the various concentrations given. Parts of the wet strips were then exposed one inch (2.5 cm.) from a Series 1 safelight for 2, 5 and 10 minutes and all developed. The resulting densities show that when the treatment was sufficient to prevent fog, bleaching occurred. Under these conditions, in a concentration of 1/1,000,000 the film increased in density, while with 1/100,000 the latent image was bleached. When a Series 0 safelight was used, the change took place between 1/100,000 and 1/50,000.

Table III.

Effect of Red Light on the Density of Pre-exposed Film Desensitized for 5 minutes with Different Concentrations of Pinakryptol Green

No.	*Concentration of Pinakryptol Green*	*Time of Exposure to Red Light*			
		None	*2 min.*	*5 min.*	*10 min.*
1	none	0.92	0.99	1.19	1.55
2	1/10,000,000	0.91	0.98	1.15	1.40
3	1/1,000,000	0.89	0.98	1.12	1.26
4	1/100,000	0.88	0.76	0.47	0.24
5	1/50,000	0.89	0.82	0.45	0.19

In the case of a developing paper which showed bad abrasion, it may be of interest to note that when bathed in pinakryptol green and exposed to red light, a latent light image was destroyed without affecting the abrasion.

Carroll[6] found that pinakryptol green destroyed a latent image on process plates in the dark in a few hours. A test on motion picture negative film showed that after a week the latent image of a step tablet exposure was appreciably diminished. After three months it was again tested and found to have nearly the same threshold exposure, but the contrast was much less. With fine grained emulsions, the bleaching would no doubt take place much more rapidly. We may conclude, therefore, that it would not be safe to desensitize exposed negatives and then keep them for any considerable length of time before development.

D. *Fog Produced by Pinakryptol Green in a Preliminary Bath*

Many dyes which have a strong desensitizing action are such bad fogging agents that they cannot be used for this purpose. Pinakryptol green has some fogging action, and this fact must be considered when using it. The intensity of fog produced as well as the effect on the speed of development varies greatly with different developers.

In order to find something of the extent of such variations, strips of motion picture negative film exposed uniformly along one edge were dipped into a 1/10,000 solution of pinakryptol green for 5 minutes, wiped with a chamois, and lowered into a tube of developer at regular intervals so that a range of development times was obtained on the same strip. Comparison strips were made by

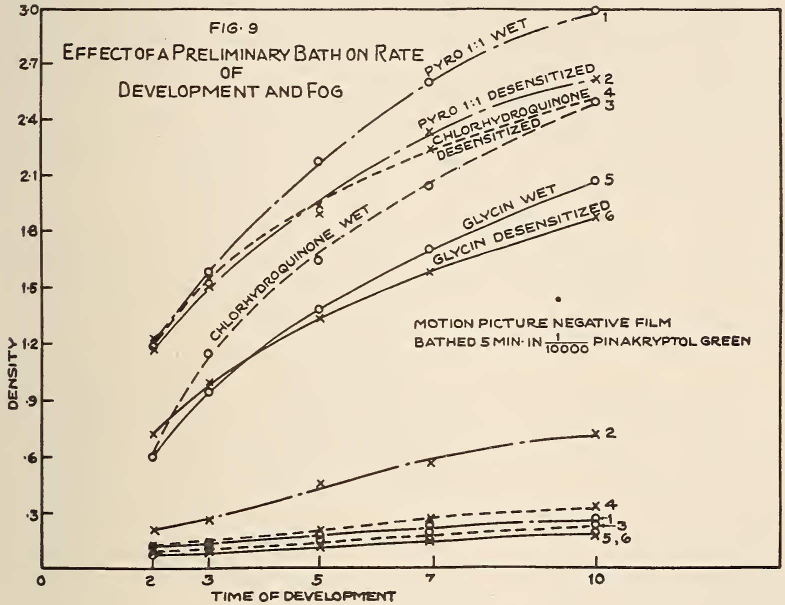

Fig. 9.

soaking in water instead of desensitizing. The densities of the image and fog were then plotted against time of development. Typical curves for three different developers are shown in Fig. 9.

With pyro 1:1 (B. J. formula) the fog on the desensitized strip was enormously increased, and although the first appearance of the image was accelerated its later development was greatly retarded. Dilution of the pyro to 1:1:2 did not appreciably change the retarding or fogging action for a given degree of development. With chlorhydroquinone, the fog was somewhat increased for a given time, but the initial accelerating action on development was so great that it extended throughout any ordinary development time. With glycin no fogging action occurred, the image appeared sooner on the desensitized strip, but the growth of density on prolonged development was retarded. From these curves it is evident that pinakryptol green in a preliminary bath affects fog and rate of development very differently with different developers, and whether it retards or accelerates development depends on the particular point at which a comparison is made. These facts show why conflicting statements on this subject might easily occur in the literature.

It should also be mentioned that a desensitizing bath which has been standing for some time in a tank may accumulate a scum on the surface which must be removed before using or it will stick to the surface of a film and cause bad smeary fog.

The data in Table IV were obtained from curves similar to those in Fig. 9. These values merely indicate the variation in the effect on rate of development and fog with several developers.

Effect of a Preliminary Bath in Pinakryptol Green on fog and time of Developement with Various Developers

Table IV.

Developer	*Time in minutes required to reach the same image density*		*Fog for same image density*	
	Soaked in water	*Desensitized*	*Soaked in water*	*Desensitized*
Pyro	3½	4	0.15	0.33
MQ-100* (Elon)	4¾	6¼	0.18	0.19
MQ–80 (Elon 80%, Hydroquinone 20%)	3½	4¾	0.16	0.21
MQ–25 (Elon 25%, Hydroquinone 75%)	2½	3¾	0.14	0.24
MQ-O (Hydroquinone)	10¾	10½	0.33	0.38
Chlorhydroquinone (MQ Formula)	5¼	3¾	0.14	0.16
Caustic Glycin	7¼	8½	0.13	0.14
Rodinal	5½	7¼	0.20	0.12

* MQ formula: developing agent 5 grams, sodium sulphite 75 grams, sodium carbonate 25 grams, and potassium bromide 1.5 grams per liter.

Among these developers only rodinal showed a distinct decrease in fog on the desensitized film, while with glycin and elon there was no appreciable change. It should perhaps be emphasized that 5 minutes treatment in a 1/10,000 solution is a longer time than is required in most cases for satisfactory desensitizing, but a shorter treatment would only diminish these effects and not eliminate them. Phenosafranine, which is generally stated to give no fog, was tested in the same way as the pinakryptol green with similar results. With pyro the fog was bad, with MQ–100 no additional fog was produced, and in both cases development was retarded. It appears from the data obtained in these tests that the fog produced in a developer after desensitizing is closely related to the tendency of that developer to precipitate the dye. Possibly the precipitate formed in the emulsion has some sort of nucleating effect and so promotes the growth of fog.

E. *Useful Life of a Desensitizing Bath*

The instructions furnished with pinakryptol green state that the solution should be kept in the dark, so it is probably light sensitive. However, solutions have been kept for several weeks in an ordinary dark room in which a skylight was frequently open without noticeable decrease in strength.

The solutions of concentrations 1/5000, 1/10,000, 1/25,000 and 1/50,000 used in tests previously described were also tested for exhaustion. Over a period of 10 days a total of one hundred 8″×10″ sheets of panchromatic film per gallon (equivalent to about 500 feet of motion picture film) were desensitized, and at the end of that period a test showed an average difference of about one step on the tablet used for these tests. Inasmuch as two steps on the tablet doubled the exposure, and desensitizing is proportional to concentration, this indicated a loss of about 25% in the active concentration of the bath. More stock solution could be added to keep up the strength for further use, but a difference of that magnitude should be well within the limits of safety allowed. A tank of desensitizing bath could therefore be used at least as long as a tank of developer, and by occasional strengthening, its life could be extended very greatly. We have no indication that the fogging action or retarding effect on development is greater in old solutions than in fresh ones of equal desensitizing power.

Wooden racks become stained when used repeatedly in a desensitizing solution, and so a test was made to see if the dye were sufficiently absorbed by dried cypress wood to interfere with the activity of the bath. The effect, if any, was found to be inappreciable.

Small amounts of hypo up to 0.1% were added to a pinakryptol green solution, and even after considerable use there was no indication that the hypo interfered in any way with the desensitizing action of the dye.

VI. The Use of Pinakryptol Green in the Developer

A. *Solubility in Developers*

The most serious difficulty in using desensitizers in the developer is their tendency to form a precipitate with certain developing agents. The insoluble substance formed is apparently a combination of the dye and developing agent which forms in alkaline solutions. If the developer is oxidized, the reaction reverses and the dye reappears in the solution. The formation of the precipitate is greatly retarded by the presence of quinone or oxidation products of the developer. For example, if a developer is partially oxidized by standing exposed to air or if 5% to 10% of exhausted developer is added to the fresh solution, much less trouble from precipitation occurs.

In this respect hydroquinone gives the most difficulty of any developer tried in this laboratory. The dye can be used in elon-hydroquinone developers in which the concentration of hydroquinone is not too high. For example, in the elon-hydroquinone tank developer (MQ–80 tank) it can be added to a concentration of 1/25,000; in regular MQ–80, only about half that amount will remain in a fresh developer, while with No. 16 motion picture developer, less than 1/100,000 is soluble. With pyro-soda 1:1 (B. J. formula) 1/25,000 precipitates if the solution is protected from the air but in a tray oxidation takes place so rapidly that the precipitate may not form. When diluted 1:1:2 as usually recommended, if the developer is kept from oxidizing, the precipitation takes place in the same way.

Chlorhydroquinone (adurol) gives only slightly less trouble than hydroquinone. Para-aminophenol with carbonate or with caustic alkali in the form of rodinal, glycin, and elon either do not give a precipitate, or if one forms in a concentrated stock solution, it readily redissolves on dilution of the developer for use. These facts are discussed fully by Luppo-Cramer[8] (Bright Light Development, p. 52).

When precipitation in a developer is likely to occur, it is very important to add the desensitizer very slowly with constant agitation and to use as dilute a stock solution as is convenient. When a precipitate once forms because of a high local concentration, it dissolves very slowly if at all.

We have never been able to prepare successfully a phenosafranine-hydroquinone developer as frequently recommended in the literature.

B. *Effect of Concentration and Time of Bathing on Desensitizing*

With pinakryptol green and most other desensitizers, the effectiveness is greatly increased by the presence of the developer, and therefore the concentration of dye required is much less than when used in a water solution. In Figs. 4 and 5 curves are given which show the comparative desensitizing action of pinakryptol green in different concentrations when used in the developer and in a preliminary bath. From these curves it is evident that a concentration of 1/25,000 in an elon-hydroquinone developer produces more desensitizing in a given time than a 1/5000 solution in water. In view of this fact Hubl[5] has suggested that development be started with an old developer containing desensitizer and completed in a fresh developer without desensitizer. He also states that after a preliminary bath the desensitizing is increased when the film is put into the developer rather than the dye being washed out. This, of course, does not apply to desensitizers which are made inactive by sulphite.

C. *Limits of Safety in Exposing Desensitized Film to different Safelights*

In Table II, data are also given which show the safe time of exposure to different safelights after desensitizing with different concentrations of pinakryptol green in the developer. It can be seen that panchromatic film can easily be made safe for the bright green light Series 4 but not for bright red lights. Motion picture negative film, on the other hand, can easily be made safe for the Series 0 or even Series 00 safelight.

D. *Fogging Action of Pinakryptol Green when used in the Developer*

It is stated by the manufacturers of pinakryptol green that it diminishes development fog, and a similar effect was found by Amor[4] for several desensitizers. The effect of pinakryptol green added to the developer in concentrations between 1/25,000 and 1/100,000 was studied for several different developers, including glycin, rodinal, elon-hydroquinone, and pyro. Motion picture negative film was used. In most cases it was found that both the development of the image and the growth of fog were retarded. The effect of shortening the induction period is the same as when used as a preliminary bath. However, for the same image density, in most cases the fog was slightly less when desensitizer was present. The decrease in fog density varied from 0 to 0.04 with different developers for normal development and was not therefore of sufficient magnitude to be of very great practical importance. In no case was any serious fogging action detected when the dye was used in the developer.

E. *Comparative Desensitizing Action During Exhaustion of Developer*

In order to find whether the desensitizer in a developer was effective throughout the life of the developer, solutions containing 1/25,000; 1/50,000 and 1/100,000 of Pinakryptol green in MQ-Tank developer were exhausted. Over a period of 10 days one hundred 8″×10″ sheets of panchromatic film per gallon were developed (equivalent to 5000 feet of motion picture film). At the end of this time film desensitized in these solutions showed an average difference of three steps on the tablet exposures from the values obtained when fresh. This means that in these tests the effective concentration of the dye had decreased to less than one-half of its original value. In another set of similar solutions exhausted to half that extent, no decrease in desensitizing action could be detected. It is probable that the margin of safety would be sufficient to cover any loss of desensitizing power during the life of the developer. In case of doubt more dye may be added occasionally.

There was no indication in these or other tests that the dye affects the life of the developer.

F. *Composition of the Developer*

In this investigation only the elon-hydroquinone tank developer (MQ–80 Tank) was used for exact studies of the behavior of the desensitizing dye in the developer. This is a typical dilute elon-hydroquinone developer and is widely used for motion picture work. On account of the large amount of labor involved, the investigation was not extended to developers of different composition. Information in the literature and our general experience do not indicate any marked difference in desensitizing with any developer in which the dye is sufficiently soluble to be used satisfactorily. However, desensitizers affect the speed of development to an extent which varies both with the developer and with the particular dye used. In practice, therefore, when using a desensitizer, the proper development time must be found for each individual combination.

Summary

1. A desensitizer is used primarily to secure greater visibility during development although it also prevents aerial oxidation fog. Greater visibility may also be obtained by so choosing a safelight that the visual intensity of the light which it transmits is a maximum and its photographic intensity in relation to the emulsion used is a minimum.

2. A practical desensitizer in addition to having a satisfactory desensitizing action must not affect the latent image or the shape of the characteristic curve of the developed image. It must also not give fog or stain and should be soluble and stable in a developer. No desensitizer is known which is stable in a developer rich in hydroquinone.

3. The properties of the following commercial desensitizers have been studied in the light of the above requirements: phenosafranine, pinakryptol green, pinakryptol yellow, basic scarlet N, and aurantia.

4. The limits of safety in the use of pinakryptol green with motion picture negative and panchromatic emulsions have been determined. This desensitizer was chosen because it appeared to be the most satisfactory of the known desensitizers at the time of this investigation.

5. The comparative safety of untreated film and film desensitized for varying times with varying concentrations of pinakryptol green to different safelights has been studied. By bathing panchromatic film in a 1/10,000 solution of pinakryptol green, or after it has been in a developer containing 1/25,000 of this desensitizer for 2 or 3 minutes, inspection of the film may be conducted with safety with a Series 4 Wratten safelight containing a 25-watt bulb at a distance of 1 foot (30 cm.). Under the same conditions motion picture negative film may be safely examined with a Series O safelight.

7. A latent image on a desensitized emulsion tends to bleach out when exposed to red light. This bleaching action is greatest

with non-color sensitive emulsions. With panchromatic emulsions, the effect is not serious and after development has commenced no appreciable bleaching occurs. With desensitized non-color sensitive emulsions the safe time of exposure to a red safelight is determined by the time required to destroy the latent image and not by the time required to produce fog.

8. Data have been obtained on the fogging action of various desensitizers with developers.

9. An exhaustive study has also been made on the effect of pinakryptol green when used in the developer instead of as a preliminary bath.

Practical Importance of Desensitizers

With superspeed motion picture negative film it is possible to satisfactorily inspect the image with safety during development without the use of a desensitizer. With an 8×10 Wratten Series 2 safelight containing a 25-watt bulb, the emulsion can be given an exposure of 2 minutes at a distance of 1 ft. (30 cm.) before a visible fog is produced, which time is far in excess of the time necessary for satisfactory inspection of the film. With this film therefore the use of desensitizers is unnecessary.

With panchromatic motion picture negative film, under the above conditions an objectionable fog is produced in 10 seconds. Inspection of this film during development is therefore dangerous, and unless a desensitizer is used development should always be carried out in the dark for a predetermined time at a given temperature as determined by the preliminary development of test strips.

The use of pinakryptol green either as a preliminary bath or when added to the developer will permit of the safe inspection of panchromatic film with a Wratten Series 4 safelight containing a 25-watt bulb at a distance of 1 foot (30 cm.). The film should not be exposed to this light until it has been immersed in the desensitizing solution for at least 3 minutes.

For use, dissolve 2/3 ounce of pinakryptol green in 50 gallons of water (20 grams per 200 liters) as a preliminary bath. When used in the developer, dissolve 120 grains per 50 gallons (8 grams per 200 liters). It is usually impossible to add the desensitizer to a developer rich in hydroquinone because the desensitizer is precipitated. The dye should first be dissolved in as small a quantity of hot water as possible and then diluted with cold water or added to the developer.

Desensitizers are valuable insofar as they permit of greater visibility during development and prevent aerial oxidation fog. They are not indispensable, however, and there is always a danger of accidentally fogging an emulsion in the bright light before the desensitizing solution has had sufficient time to act. With panchromatic emulsions, their use permits of inspection of the image during development, which is otherwise not possible.

DISCUSSION

Mr. Hubbard: In all Mr. Crabtree's tables he showed a much better effectiveness of the desensitizer when it was dissolved in the developer itself. I do not think that when developing panchromatic film in the commercial way it would be possible to put the desensitizer in the developer. You would be able to handle only one rack at a time in that way. Having a separate desensitizing bath in a separate room, film could be handled more rapidly, and I should like Mr. Crabtree's opinion.

Mr. Wall: I have been playing about with desensitizers for some little time; in fact, I do nothing else but play, and I want to say that pinakryptol green is a mixture of pinakryptol and pinakryptol yellow. I was disappointed to hear Mr. Crabtree dismiss basic scarlet N, because I have found it better than phenosafranine, and although it is a mixture, it does not stain the fingers as much as phenosafranine. Chrysoidine and phenosafranine act well. The stain is removed with a weak solution of hydrosulphite, the chemical constitution of which is $Na_2S_2O_4$.

With regard to the bleaching action, I should like to ask Mr. Crabtree whether he has any support for the theory put forward by Luppo-Cramer that the bleaching action is due to the presence of bromide with these dyes. He obtained a reversal of the image and enormous color sensitizing using desensitizers with bromide and found that even sensitizers act as bleachers.

With regard to the precipitation in the presence of hydroquinone, if you can use a developer with metol in excess, it will not precipitate. I don't know why, but take an ordinary plain hydroquinone developer, and it will precipitate, but with metol there is no precipitation.

Dr. Hickman: Perhaps the reason the mixture of two dyes does not stain the fingers is fairly well established. Both are colloids and one protects the other in a mixture.

Dr. Sheppard: I should like to refer to one point raised by Mr. Wall, and that is the bleaching action of desensitizers on the latent image. In the first place we have not a satisfactory theory of the dye desensitizers. The desensitizing is probably connected with the bleaching action. The desensitizers behave as if they were only oxidizing agents in the presence of light and of the light which they absorb. A difficulty is that oxidation must take place in a strong reducing solution, the developer. That is not an absolute objection, however. If the action of the desensitizing is that of an oxidizing agent, if can first destroy certain substances present in the silver bromide which are not silver bromide but probably small specks of silver sulphide, a material the chemical properties of which are similar to metallic silver but different in certain degrees. There is also a difference between the latent image as it is formed and the already formed latent image which must be bleached out. The nascent latent image would be similar to metallic silver in the more finely divided form, but there are other factors—possibly, some peptizing action of the dye; that is, an attack on the silver bromide, which breaks up the surface and encloses the silver particles with a protective film. The theory is important, because until we get a theory we cannot make more use of desensitizers.

With regard to the action of bromide, that is in agreement with the oxidizing action in that it goes on to form silver halide in the presence of the oxidizer, which is an action more effective than oxidation of silver.

Mr. Crabtree: Mr. Hubbard is quite right that it is not possible to put the desensitizer in the developer if the film is inspected with an overhead or wall safelight. The only practical procedure is to give a preliminary bath in an adjacent room. On the other hand, the man in a small way inspects his film with a small hand lamp such as a pocket flashlamp. The hand lamp has the advantage that if the light is powerful enough to cause fog, the whole film is not fogged as with the wall safelight.

In reply to Mr. Wall about basic scarlet N, there seems to be a difference of opinion as to its composition, but Lumière and Seyewetz state that it is a mixture of safranine and auramine.

Dr. Sheppard very well answered the question with regard to the bleaching action of desensitizers. I think it is quite right that with a high concentration of elon the desensitizer does not tend to precipitate in a developer. By blowing air through the developer in which the dye is precipitated, the desensitizer goes into solution again.

Mr. Wall: With regard to the composition of basic scarlet N, it has been stated to be a mixture of chrysoidine Y and safranine, which I think is correct.

With regard to precipitation in the developer, addition to the developer of more alkali, such as caustic soda or potassium carbonate, dissolves the precipitated desensitizer in a hydroquinone developer.

With regard to Dr. Sheppard's remarks about oxidation, I should like to ask about the statement of Seyewetz that the desensitizing action can be removed by washing. I do not know whether this is possible.

Mr. Crabtree: I think Mr. Wall is right that with certain developers an increase in the alkalinity prevents precipitation, but we are dealing only with motion picture developers. You cannot change the alkalinity, and you have to add so much caustic soda to the developer to prevent precipitation that the developer is then of no practical use. We have not examined as many different developers as we might have to determine under what conditions precipitation takes place, but an ordinary elon-hydroquinone containing the desensitizer has a reasonable life.

Dr. Sheppard: With regard to Mr. Wall's point about the washing out of desensitizers, this does not affect oxidation to any appreciable degree. There is no desensitizing if the dyes are not present during exposure to light. There are specific classes of desensitizers. You can use chromic acid or permanganate to desensitize an emulsion by bathing before exposure to light, and that desensitizing action will take place if you wash out the desensitizer before exposure to light; that is, the permanganate has oxidized the sensitivity centers I am speaking of. Then, you can have copper salts and iron salts, which exert a certain measure of destructive action before exposure to light; that is, like the effect of chromic acid or permanganate, but they act during the actual time of exposure. Their effect is reduced by washing them out before exposure, because as Mr. Wall has pointed out previously, the action is largely on the nascent latent image and these bodies may not be entirely removed by washing. Finally, you have the class of dye desensitizers discovered by Luppo-Cramer in which the action is connected with absorption during exposure. If washed out before exposure, the potential oxidizing action is not stimulated. They have an effect on the nascent image, so that I don't think the washing out affects the question of oxidation in one way or another; at least, I don't think it is essential.

LIGHTING AND THE CAMERAMAN

Harry Fischbeck*

BECAUSE the motion picture film cannot be retouched or altered after taking, the cameraman must rely solely on his instrument for the finished effect. Apart from composition, his

Fig. 1. The spotlight picks out the boy on the wall, while back lighting emphasizes the dark figures of the pursuers.

control is limited to lighting and exposure, each of these requiring careful study and long experience for skillful handling.

The first requirement is softness and modeling with an absence of glaring whites and sooty blacks; the light must be regulated to produce an even range of tones. Even where this has been accomplished for the set itself, trouble may be caused by the lack of harmony in the make-up and dresses of the many characters who may be on the scene. The "star" has to be isolated and the other performers

* Famous Players–Lasky Corporation, Long Island City.

empasized in their order of interest. That the spotlight may achieve this effect is shown very clearly in Fig. 1, where the boy on the wall is thrown into striking relief, while the other characters are suggested more by their sinister shadows than by actual details. A similar but less obvious result is attained in Fig. 2. Here, among some nine

Fig. 2. In an evenly illuminated scene the spotlight stresses the man on the extreme right and the woman on the left.

performers in an evenly balanced scene, two, the prince on the extreme right and the lady of his attentions on the left, require emphasis. The spotlight has accomplished this and done it so unobtrusively that we are almost unconscious of the means.

The artist with the camera, like the artist of the canvas, strives to "paint" his figures against an appropriate background, making them stand out and convey an illusion of solidity. Contrast is the key to this accomplishment where the tones of subject and set must be separated sufficiently to throw the story material in vivid relief. Though the characters may be clothed in light or dark suits or dresses, the cameraman picks out personality or background with his spotlight to secure the right expression.

Contrast and key of a picture are not only matters of relative lighting but of absolute intensity also. Varying the exposure by altering the lens stop or the angle of the shutter plates enables the operator to control the amount of sparkle in the finished picture.

FIG. 3. Spotlights concealed behind the rafter illuminate the recumbent figure and visitor as though from the ceiling lantern.

Long exposure may be used to render detail in shadows of a low key, to give quality and subdued tonal values; short exposure is pressed into service for snappy, vigorous outline and repression of unwanted patterning in the darker parts of the subject.

If the finished film cannot be retouched, the subject matter certainly can. Many a good heroine, an excellent actress but photographically unattractive, has been turned into a ravishing damsel by the skillful application of powder and paint. Here the cameraman, if he possesses that intimate and very necessary knowledge of color values and the color rendering of his film medium, can offer tactful suggestions which may point the way from disaster to success.

Not only is the quality of the light important but also its direction. A scene with a bright cloudless sky on one side and a thunder shower on the other would look unnatural if the sun's rays and hence the shadows of the subject appeared to emanate from the thunder cloud. So also must the cameraman be careful that his rustic hero reading by the light of a single candle in a cottage does not appear too obviously emblazoned by a dozen sun arcs concealed in the ceiling. An example of clever imitation of natural lighting is the sick bed scene of Fig. 3, where the invalid is lighted by a radiance apparently from the lamp hanging on the central rafter, while the room is suffused by a quiet fireglow. The film was first run through the camera with the lamp removed, the lighting being by studio illuminants, and was then wound back and passed through a second time with the ceiling lantern in place but the other lights extinguished.

Even in so short an article, enough has been said to lay stress on the importance of lighting in securing quality and faithfulness of rendering. It remains to close with an exhortation to the cameraman to study the control of light and exposure as the very life source of his professional activities.

APPARATUS FOR TIME LAPSE MOTION PICTURE PHOTOGRAPHY

Howard Green*

WITH the rapidly growing importance of motion pictures as a means of disseminating information among farmers, the Office of Motion Pictures of the Department of Agriculture has for some time felt the necessity for providing means of making motion pictures of such natural processes as seed germination, mould formation, plant growth, the development of plant and tree diseases and the like—processes that are too slow to be photographed by hand cranking. Some work of this type was done by hand, using the stop-motion crank, but the obvious limitations of this method made it impracticable. The first machine, as far as this office is concerned, for doing the work automatically was built by Mr. George Georgens, in charge of the laboratory of this office. Lack of time and facilities, however, interfered with carrying this experiment to a conclusion.

The new machine (Figs. 1 and 2) which was designed and built in this office by the writer, has done satisfactorily all that it was intended to do so far. It is entirely automatic both as to timing and the handling of the two Cooper-Hewitt lights used for illumination. It can be instantly set to operate at any interval from thirty seconds to one hour. It switches on the lights, allows them to burn long enough to attain maximum brilliance, makes the exposure of one frame of film, cuts off the lights, and stops action until the next interval has passed. The time intervals can be changed even while the machine is running by simply turning a disc, which is automatically held where set by a spring detent. The time of exposure or duration of shutter opening also is variable.

The entire control of timing and operation is vested in an eight-day double spring clock movement. The clockwork operates a small mercury switch through the variable timer, which is between the clockwork and the mercury switch, and the switch starts the motor which does the actual work. The motor, through a high-ratio gear reduction, drives a rotary switch controlling the lamps, and a cam on the end of the rotary switch shaft actuates the camera. When the

* Office of Motion Pictures, Extension Service, Department of Agriculture, Washington, D. C.

motor is started by the clock switch, it turns the rotary lamp switch and the camera drive through one complete revolution and no more. When the revolution has been completed, the rotary switch shaft is automatically disengaged from the motor drive, and it cannot make another revolution until the motor has been stopped and

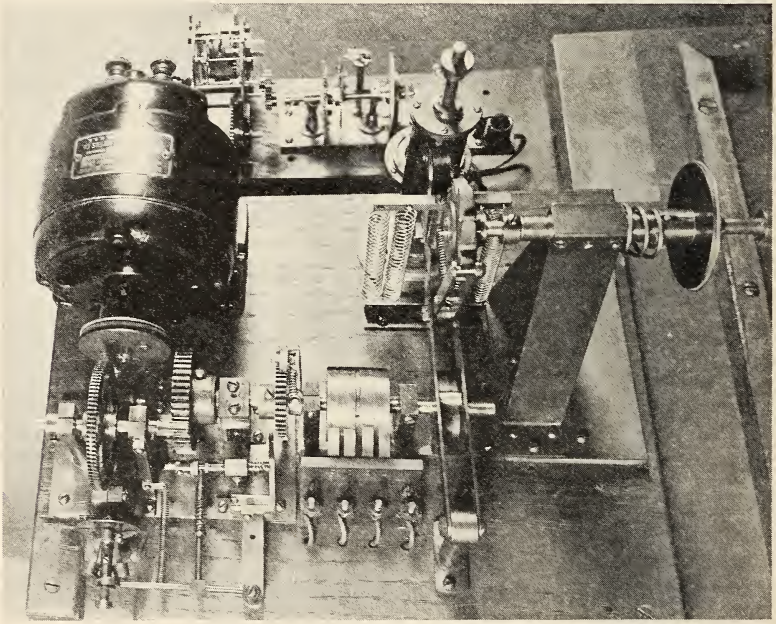

Fig. 1. Aerial view of time-lapse mechanism.

started again. This precludes the possibility of making more than one frame at a time. The motor continues to run for about fifteen seconds after the lamps have been cut out and then is stopped by the opening of the mercury switch. Thus when there is no work for them to do the motor does not run and the lights do not burn.

To see how this is worked out, let us go back to the clock control. The clock drives a shaft which makes one revolution an hour, and the end of this shaft carries a gear having sixty teeth—a tooth for each minute. A second shaft, through which the mercury switch is operated, extends in the same axial line as the one-hour shaft, and it is driven by the one-hour shaft through a radial arm on the switch shaft, the arm carrying a pawl which engages with the teeth of the sixty-tooth gear on the one-hour shaft. With the pawl in engagement with the sixty-tooth gear, the mercury switch shaft is turned at the same rate as the one-hour shaft. On the switch shaft is a watch mainspring which tightens as the shaft turns and tends to force the switch shaft, with its arm and pawl, in the direction opposite to its rotation. If, while the switch shaft is turning, the pawl is thrown out of engagement with the sixty-tooth gear which drives

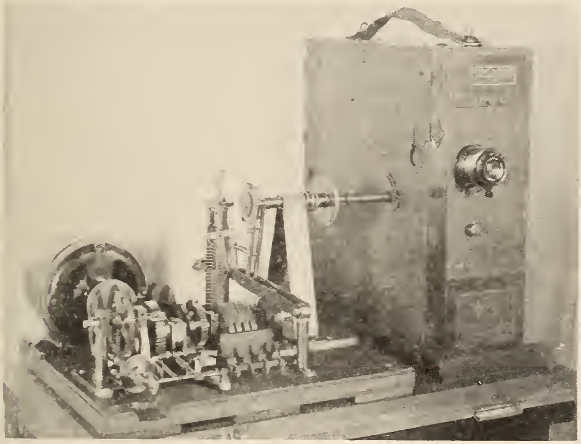

Fig. 2. Time-lapse apparatus connected to camera.

it, the switch shaft will fly back until it brings the radial arm up against a stop. It is this back action which closes the switch. Movement of the switch shaft in the same direction as the one hour shaft opens the switch. A trip is provided which can be set at any part of the circle described by the pawl. When the pawl reaches the trip, it is thrown clear of the gear teeth and flies back against the stop and in doing so closes the mercury switch and starts the motor. When the pawl comes up against the stop, it is again engaged with the gear and at once begins to move with it, opening the switch and then moving on until it again comes to the stop and repeats the action. If the stop is set at the distance of one gear tooth from the stop, the pawl will occupy one minute in moving from the stop to the trip, and the switch will therefore be operated at one-minute intervals. If the trip is set five teeth from the stop, the switch will operate at five minute intervals, and so on up to sixty minutes.

The switch itself consists of a horizontally pivoted lever with a downwardly projecting point dipping into a cup of mercury, the lever being normally held in the open circuit position by a light spring. The lever has a short projection back of its pivot; an upward pressure on the short end throws the point down into the mercury, and upon removal of the pressure the point is lifted out by the spring. The pressure is supplied through a radial arm on the switch shaft at the end opposite the driving end, and this arm is brought against the lever when the pawl, having been tripped, returns to the stop. As the pawl again engages and moves away from the top the switch is opened. The time during which the switch is closed is determined by the depth of the switch point in the mercury in the cup. The clockwork, the timing gear and switch are assembled in a unit which can be removed and placed at any distance from the machine and connected by two wires, thus constituting a remote control. We have found it more convenient, so far, to leave it in place on the stand.

The motor controlled by the mercury switch does all the real work. It drives a rotary lamp switch handling the two Cooper-Hewitt M tubes and operates the camera through a cam on the end of the rotary switch shaft. Drive to the rotary switch shaft is through a combination of worm and spur gearing giving a total reduction of 960 to 1. The switch shaft makes one revolution in thirty seconds, while the motor runs for ten or fifteen seconds longer. The rotary switch is not mounted on the low speed gear shaft but on a second shaft in the same axial line driven through a radial arm with a pawl engaging the teeth of a gear on the low speed gear shaft; the pawl is normally held in engagement by a spring, but is thrown out at the end of one revolution by a trip which, by a rather peculiar action, throws it clear of the teeth. The trip throws out the pawl and stops the rotation of the switch after the lamps have been turned off.

It is necessary now to get the pawl back into engagement, so that when the timing switch again starts the motor, the rotary lamp switch and the camera operating mechanism will function. On the worm shaft, which runs at high speed, there is a device of the centrifugal governor type. When the motor starts, the weights fly outward and move a sleeve and collar along the shaft, and the collar actuates a finger which pulls the trip clear of the pawl, allowing the pawl to drop into engagement. The action is very rapid, so that the rotary switch starts only a fraction of a second after the starting of the motor. The finger which released the trip meantime allows the trip to return to its original position, so that, having allowed the pawl to engage and pass, it is ready to throw it out at the end of the revolution.

It will be seen that once the rotary switch has stopped, it cannot start again until the motor stops and once more starts, causing the release of the pawl. If, however, the clock is stopped with the mercury switch closed and the rotary switch trip is held back, the motor, the rotary switch, and the camera operating mechanism will run continuously, and as one revolution is made in half a minute, the camera will make one exposure every half minute.

The camera is actuated through the regular hand-crank shaft which makes eight frames each revolution and so has to be turned an eighth of a revolution to expose one frame. This is accomplished by mounting an eight-tooth ratchet on an extension of the crank shaft and operating the ratchet and shaft through a pawl on an upwardly extending arm which is raised by a cam on the end of the rotary switch shaft and pulled down by springs when released by the cam. The speed of the drop, and consequently the time during which the shutter remains open, is controlled by an air dashpot with an adjustable valve. The smaller the opening of the valve, the more slowly the air will escape and the longer will be the time required for the shutter to close. A friction disk on the extension shaft checks the tendency of the camera gearing to overrun and allow the shutter to swing too far.

The machine has proved very steady and reliable in action, and it has been allowed to run for weeks at a time, day and night, without any fault being found in its functioning. Occasionally the supply of current has been interrupted. When this happens, naturally the motor stops and the lights go out. The clock of course, continues to run and to operate the little mercury switch. When the current supply is resumed, it may catch the clock switch entirely out of time with the rest of the machine. This, however, takes care of itself, and automatically the proper relationship between the various parts is resumed in the next cycle. The worst that can happen is that a single frame may be spoiled, but even this is unlikely. It will simply pick up where it left off and go on running as if nothing had happened. On one occasion, the line voltage dropped so low that though the motor kept on running the Cooper-Hewitts would not start. The result was a series of blank frames indicating just how long the voltage drop had continued. By counting frames, the exact time of the drop was determined, and just as a matter of interest this was checked up with the power house records and found correct.

REPORT OF PAPERS AND PUBLICATIONS COMMITTEE

May, 1926

WITHIN the knowledge of your committee this is the first occasion on which the Papers and Publications Committees have been combined. Previous to the term of President Jones, President Porter recommended a combination of the two committees, and this recommendation was adopted by the Board of Governors. President Jones, however, requested a reversal of this decision, and during his term of office the two committees functioned separately.

In October 1925, at the request of President Cook, the present chairman undertook to try the experiment of combining the duties of the two committees. A six months' trial of this combination has shown that this is highly desirable because the functions of the two committees are so closely inter-related. The Chairman of the Papers Committee is fully acquainted with the various papers and is in a better position than a separate Publications Committee to see that the papers are published correctly.

The serious difficulty in the way of a successful working of this combination is the enormous amount of effort and time involved. The work requires the expenditure on an average of at least an hour every day apart from the time of a stenographer. It is extremely doubtful if the Society will be fortunate enough to find individuals whose employers are willing to permit them to devote so much of their time to the interests of the Society. Spasmodic efforts are of little value. From three to four months are required to publish the two volumes of the Transactions and at least three months to prepare the program. The work of publishing the Transactions is such that it cannot be efficiently carried out by several individuals widely separated geographically. Unless the committee members are located in one city, it is necessary for one individual to do the work. At least one year's experience is necessary for the chairman to become thoroughly efficient, so that yearly changes of chairmanship are undesirable from the standpoint of the welfare of the Society. It is doubtful, however, if any person would care to shoulder the burden of work for more than a year.

The only relief for the situation is the establishment of a permanent secretary. This matter has been under careful consideration by the Board of Governors but no definite action has been taken because of the difficulty involved in raising the necessary money.

Report of Publications Committee

Discussions after the Roscoe meeting were returned by authors promptly. The lettering on some of the illustrations was too small to be visible, and it was necessary to redraw fifteen diagrams.

The Chairman is greatly indebted to Miss Schmitt, our recording secretary, for valuable assistance in correcting and punctuating all discussions and manuscripts. As a result of this effort the cost of printer's corrections for Volumes 23 and 24 was less than eight dollars, which constitutes a record.

Unfortunately, the name "Schenectady' 'instead of "Roscoe" appears on the cover of Volume 23. At the suggestion of Mr. Porter, the date of the convention and not the date of publication will appear on the cover of future issues.

For the guidance of future chairmen of the Publications Committee, the following details regarding procedure in handling the publications may be of interest.

Advertising copy together with cuts should be insisted upon for the forthcoming two volumes at each meeting. This is vitally important, otherwise an inefficient Advertising Committee will cause delay in publication.

The recording secretary makes as many copies of the discussions as there are persons participating. The chairman then forwards a complete copy of the discussion of each paper to each person concerned and to each copy is attached a slip requesting return in five days. On a list of the various discussions mailed a check should be made of the returned, corrected discussions. In case the discussion is not returned within the prescribed period, the chairman should correct the discussion as he sees fit in order not to delay publication. The discussions are then clipped, assembled, and edited to make coherent logical reading. *The chairman has absolute authority to delete undesirable matter.* It is often necessary to entirely rewrite discussions corrected by authors. The edited discussions should then be re-typed for the printer.

Manuscripts of papers should be very carefully punctuated and headlines indicated. Tables should be typed so that there is no possibility of the printer erring. The size of the cut together with the caption should be written on the back of all diagrams or photographs. It is necessary to give the printer the most minute details, otherwise he will set up copy exactly as submitted by the author and some authors are not acquainted with methods of arranging manuscript for typesetting.

The manuscripts with appended discussions, advertisements, and cuts should then be forwarded ensemble to the printer. A contract should have been previously secured from the printer regarding prices and arrangements for mailing. When submitting copy to the printer, it should be accompanied by a list of addresses of authors and advertisers, so that the printer may forward galley proof directly to authors and advertisers with an order blank for reprints. The galley is then returned by the authors and advertisers to the chairman, who must then carefully re-read all papers and advertisements and not trust the matter of correction entirely to the authors, many of whom are very careless in making corrections. This submission of galley to authors is, however, very necessary in order to absolve the chairman of ultimate responsibility, although his personal pride in the accuracy of the Transactions should spur him to correct all copy personally. The galley is then returned to the printer together with a make-up sheet indicating the order of insertion of papers and other details concerning committees, etc., for which previous volumes of the Transactions may be taken as a model. This should not be left to the printer, however, who has other business and worries. Page proof is not submitted to authors but is returned by the printer to the chairman, who must check it carefully to insure all corrections having been inserted. Final page proof, submitted to the printer must be accompanied by a corrected list of addresses of members, instructions as to the number of copies and reprints required, and a mailing list of advertisers, which should be secured from the Advertising Committee. Many advertisements are handled by agents, to whom the copy must be sent for checking purposes.

The printer mails one copy of the Transactions to each member, one to each advertiser, and usually one hundred to the secretary, the remainder being kept in storage. The printer also retains in storage all cuts used in previous Transactions.

This entire procedure involves an enormous amount of work, but acceptance of the position as chairman of the Publications Committee involves the responsibility entailed.

Report of Papers Committee

There is usually less difficulty in securing papers for the spring than for the fall meeting because of the material which has accumulated through the winter. Experience has shown, however, that very few persons, including members of the Society, will offer papers without being approached. This is possibly a result of modesty, but all members should realize that the Society is their society and that the least they can do for it is to put on record in the Transactions any information which they are in a position to publish.

In constructing the program for the Washington meeting, your committee kept strictly in mind the remarks contained in the address of President Jones in the No. 23 Transactions; namely that the object of the existence of our society is "advancement in the theory and practice of motion picture engineering and the allied arts and sciences, and standardization of the mechanisms and practices employed therein, etc." The Society is, therefore, concerned with all branches of the motion picture industry from scenario writing to theatre management. In the past the branches of production and theatre construction have been somewhat neglected, so an effort was made to secure a preponderance of papers dealing with production. Your committee was only partially successful in this venture. It will apparently be necessary to interest the heads of the various producing concerns before the Society gets any active co-operation from producers in general. The various technical men concerned are quite willing to assist, but unless they are allowed the necessary time for writing papers by their superiors the securing of papers will be a very difficult matter.

An attempt has been made to devote the Wednesday morning program to a symposium on the "film in the theatre" and the afternoon program to a symposium on "production."

Respectfully submitted,

J. I. Crabtree *Chairman*
C. E. Egeler
L. A. Jones
L. C. Porter
Wm. F. Little
J. C. Kroesen
J. A. Summers

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OF THE

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TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

Volume X Number 27

MEETING OF OCTOBER 4, 5, 6, 7, 1926

BRIARCLIFF, N. Y.

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PRESIDENTIAL ADDRESS

Fall Meeting of the Society of Motion Picture Engineers

Briarcliff, N. Y., 1926

W. B. Cook*

Fellow Members and Guests:

As stated in our Constitution, the object of the Society of Motion Picture Engineers is the 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. Every phase of the motion picture industry is benefitted by the papers prepared and the discussions that follow their reading. Upon the members of our Society rests the responsibility that the motion picture production—created for the entertainment and instruction of the public—shall be properly prepared in the studio, developed and printed in the laboratory, distributed to the exhibitor and perfectly presented at the theater.

Through its members, the Society originates new and improved devices, processes and methods, and acts as a clearing house for the dissemination of this information to those who will be benefitted by it.

The meetings of the Society of Motion Picture Engineers are not in any sense sales conventions and their main purpose is to exchange ideas and encourage the development of matters of a technical nature. The members, for the time being, are not directly concerned with the commercial side of the industry, but their activities are of a very practical nature and directly influence the prosperity and progress of the entire motion picture industry. The Society is gratified by the encouragement and support received from some important sources, but feels that the motion picture industry, as a whole, is not as well acquainted with the activities or as appreciative of the work of the Society of Motion Picture Engineers as it should be.

The very foundation of the Society of Motion Picture Engineers rests on its scientific members and it is the nature of these men to work quietly and alone.

* Kodascope Libraries, Inc., New York, N. Y.

In recent years, however, there has been a growing tendency in large manufacturing enterprises to utilize practically the abilities of scientists and technicians, and the world has thus derived almost incalculable benefits from this co-operation.

During the seven years it has been my privilege to be a member of the Society, I think at every successive convention we have taken up the problem of co-ordinating the work of the Society more closely with the big producers and distributors. While we have a few members who are representatives of the individual units in the big producing studios and possibly one or two among the distributors, there is no general tie-up between our organization and those directly connected with the production and distribution. We have sought in vain for some sort of contact, and until the last year we have made no progress. Now, during the past year we have made flourishing progress in this direction. We have not only one or two members who are influential in the producers' class, but we have a tacit agreement from the Producers' and Distributors' Association that they regard the co-ordination of our efforts for the solution of their problems as a very desirable thing. Tonight we will see and hear substantial evidence of this progress at the dinner we are giving Mr. Hays, who is the head and moving spirit of the Producers' and Distributors' Association. There is every reason to believe that our hopes and ambitions for a closer co-ordination of our efforts with their requirements is about to be realized, and it is something in which I know you will all share with your executive and Board of Governors in the feeling of satisfaction for the successful culmination of our efforts.

PROGRESS IN THE MOTION PICTURE INDUSTRY

REPORT OF THE PROGRESS COMMITTEE

October 1926

Introduction

TOO often historical references are very incomplete due to a lack of appreciation, at the time events occur, of their future value or significance. Motion pictures in the future will be of even greater value than were still photographs in the past and the request recently made to President Coolidge, that twenty vaults of the proposed two million dollar Archives Building be set aside for the storage of films of value to posterity, is worthy of especial attention.[1] The President expressed himself as being favorably impressed with the idea.

Projection with the 16-mm. film has received widespread publicity during recent months and the use of this film is becoming more and more extended for both professional and amateur service. Many salesmen are finding it to be a very useful aid in displaying and advertising their wares, while in the home, the taking and projection of motion pictures is becoming a fad in some circles.

A British producer is building a film city[2] modelled after the American film center, Hollywood; it will be located on a forty-acre estate at Borehamwood, Hertfordshire. Two studios 300 by 200 feet and 40 feet high form the nucleus of the plant.

Interest continues in television. English radio fans have had the chance to "hear a man's face."[3] Experimenting in this new field, a British engineer has been broadcasting his face on a 200-meter wave length which registers in ordinary receiving sets only as a continuous hum but when the television apparatus is hooked in, his face is thrown on a screen so that his listening audience may also see him. The British government has just issued the first two television licenses on record.

The most recent contribution to the art of talking motion pictures has been the activity of a prominent producer in conjunction with leading telephone engineers on the apparatus known as the "Vitaphone."[4] The cinematographic feasibility of this device was

[1] "Time," Sept. 13, 1926, p. 17.

[2] "Kinemat. Weekly," 107, Jan. 7, 1926, p. 101.

[3] New York "Sun," Sept. 13, 1926, p. 23.

[4] "Amer. Cinemat.," Aug., Sept., 1926, pp. 26, 10.

perfected in a comparatively short period of time and applied to the production "Don Juan."

Respectfully submitted,

C. E. Egeler, *Chairman*
J. I. Crabtree
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Cameras

A new double-speed mechanism has been announced[5] for the Eyemo camera which permits the taking of pictures at the rate of thirty-two exposures per second in addition to the standard speed of sixteen per second and which may be embodied in cameras now in use. The increased speed is accomplished instantaneously by manipulating a speed adjusting lever located on the face of the camera. Several improvements[6] have been made upon the Cine Kodak and Kodascope for amateur use, including the use of a lens of greater speed and the addition of a sight finder. A new hand-cranked motion picture camera[7] for amateur or professional use employing 35mm. film and equipped with an f/5 lens, focusing mount, external film retorts, footage meter and direct vision finder, has been designed to sell at a moderate price.

A British innovation[8] is one in which differently placed synchronously driven cameras can be used to enable a continuous record from a plurality of viewpoints to be made without interrupting the action in the scene being photographed. One or more of the cameras may be provided with means for photographically recording sounds.

Many improvements have been made in camera accessories, among which is a range finder[9] based on the coincidence principle.

Color Photography

Color photography research is leaving the old stereotyped lines and is branching out into more fundamental fields, however as yet with only partial success.

[5] "Amer. Cinemat.," Sept., 1926, p. 12.
[6] "Amer. Cinemat.," May, 1926, p. 10.
[7] "Photo-Era," 56, May, 1926, p. 286.
[8] British Patent 243,690—To The DeForest Phonofilms, Ltd.
[9] "Kinotechnik," 7, Dec., 1925, p. 630.

A practical disadvantage of the lenticular film system hitherto has been the necessity for employing a projector lens of the same focal length as that used in the camera. By a recent improvement[10] the lenticular elements are arranged so that the pupil of emergence is at infinity or at a great distance in front of the sensitive surface of the photographic film or plate. By this construction the images of the color selecting filters used in the objectives are independent of the focal lengths of the objectives used in taking or projecting.

Another British patent[11] covers a process in which multi-color negative or positive images of separately tinted color record negative images are produced on a film having one surface covered with minute lenticular elements in apparatus employing an annular diaphragm having an opaque central portion which covers the useful lenticulated surface, and a transparent annular portion which covers the inoperative neighboring area.

Thornton Three-Color photography,[12] which is the making of a 3-color motion picture film by the use of an apparatus with a single lens and beam splitting device and a film of double width, is described in an abstract of British Patent 238,688. One part of the film is prepared with a 2-color screen mosaic of green and violet which reproduces in the negative the magenta red and the yellow portions of the subject. The second portion of the film receives the light through an orange-red filter incorporated in the surface of the film, thus producing a full tone negative image of the blue-green portion of the subject. In making the film the color layers are coated first, then a thin substratum, and on this the panchromatic emulsion. Exposure is made through the support and color screen layers. The positive film is similarly prepared, although red, blue and yellow may be used instead of the colors employed in the negative film.

Another method of color photography[13] has been proposed in which the color is produced after development by the oxidation of leuco-dye bases with which the silver halide grains have been respectively treated. Each third of a silver bromide emulsion would be separately sensitized to one part of the spectrum, with a subsequent attachment to each of the leuco-bases of a dye of the complementary color. Complete success has not yet been achieved.

[10] British Patent 247,168—To The Soc. Mondiale du Film en Couleurs, Keller-Dorian.

[11] British Patent 245,118—To The Soc. Mondiale du Film en Couleurs.

[12] "Brit. J. Photo," Color Sup., *20*, Feb. 5, 1926, p. 8.

[13] "Phot. Ind.," *23*, Dec. 7, 1925, p. 1330.

A British patent[14] has been granted dealing with a method of producing color motion picture film, the color of which is produced by a screen mosaic. Fine pollen or spores dyed in the proper admixture are used to produce the mosaic. The poly-colored powder is mixed with gelatin and coated on film by passing a panchromatic negative film through a heated bath of the color mixture. Subsequently the film is passed over an absorbent roller which cleans off the color emulsion from the unsensitized side.

Several experiments have been made at the Lick Observatory with plates especially sensitized to the extreme red region of the spectrum.[15] Exposures were made of the planet Mars, with light of three different colors, violet, yellow and the extreme infra-red. The pictures made with infra-red light revealed much clearer details of the planet surface than could be detected with ordinary plates or seen with a telescope. Motion picture film has been especially sensitized with kryptocyanine. A new sensitizing dye, neocyanine, is mentioned, which extends the photographic spectrum much further into the infra-red than kryptocyanine.

Color photography requires the use of light of proper composition or quality in the taking of the pictures and filters are generally necessary. Investigation has been made of the theory of light absorption[16] for liquid and dry film filters, including the mathematics dealing with the selection of proper color filters. A new formula[17] which has been devised for making a daylight filter expressed in grams per square meter of film surface is thionine blue 0.175 grams; orange II, 0.14 grams; tartrazine 0.03 grams.

Films and Emulsions

The inspection of film during development is very often necessary and the use of desensitizers is one method which can be employed with panchromatic film for which only a very low intensity from the so-called safe-lights may be used. They can also be used to prevent aerial and oxidation fog, and their effect in development has been discussed[18] in a comprehensive paper presented before this Society.

In France the observations of Dundon and Crabtree[19] on the

[14] "Brit. J. Phot.," Color Sup., *20*, Jan. 1, 1926, p. 4.
[15] "Amer. Phot.," *19*, Dec., 1925, p. 678.
[16] "Sci. Ind. Phot.," *6M*, Jan., Feb., 1926, pp. 4, 5.
[17] "Phot. J.," *65*, July, 1925, p. 348.
[18] "Trans." S. M. P. E. No. 26, p. 111.
[19] "Bull." Soc. Franç. Phot., *68*, Feb., 1925, p. 28.

effect of desensitizers, particularly pinakryptol green, in preventing aerial oxidation fog, have been confirmed, and in Germany a writer[20] discusses their action for development in bright light. The action of nine desensitizing dyes on ordinary orthochromatic and panchromatic plates was examined[21] and it was found that in all cases the greatest desensitizing action occurs in the ultra-violet and blue and that for each kind of plate tetramethylsafranine and Nile blue 2B are the two most effective desensitizers. Panchromatic plates require the use of appreciably more concentrated solutions of the desensitizing dyes.

The effect of washing on desensitized plates[22] was determined by desensitizing strips of cinematographic film and washing these in the dark for periods of one minute to two hours, and, after drying, the sensitiveness was determined by means of the Eder-Hecht sensitometric screen.

A new sensitizer for the photography of infra-red[23] is called neocyanine and has a broad sensitizing band extending from 700 m. to 900 m. with a maximum at about 830 m.

Further investigation has been made toward the discovery of suitable methods of desilverization of fixing baths. For large scale silver recovery[24] from fixing baths the hydrosulfite method is considered impracticable because of the necessity of heating the bath. A modification of Steigmann's method[25] of silver recovery has been developed.

The action of photographic fixing baths and their components on various metals,[26] lead, copper, tin, iron, aluminum, zinc, brass and nickel-plated brass was determined by immersing these in the form of rectangular strips for about forty days in each of four different solutions.

Further fixing bath investigation shows[27] that the rate of fixing of Agfa cine positive film varies in different baths.

Crystalline sodium bisulfite[28] is much used for acidifying fixing

[20] "Phot. Rund.," *62*, Dec., 1925, p. 461.
[21] "Z. wiss. Phot.," *23*, Oct., 1925, p. 363.
[22] "Chim. et Ind.," *15*, Jan., 1926, p. 95.
[23] "J." Opt. Soc. Amer., 12, April, 1926, p. 397.
[24] "Filmtechnik," *1*, Dec. 5, 1925, p. 336.
[25] "Filmtechnik," *1*, Nov., 25, 1925, p. 316.
[26] "Phot. Ind.," *23*, Nov., 16, 23, 1925, pp. 1244, 1273.
[27] "Phot. Ind.," *23*, Nov., 30, 1925, p. 1319.
[28] "J." Soc. Chem. Ind., *44*, Mar., 20, 1925, p. 127T.

baths, and is rapidly challenging the popularity of metabisulfite or acetic acid for this purpose.

The retarding effect in developers at low temperatures[29] is given by Hübl's table showing the time of appearance of the image at normal temperature, as well as the retardation for a 10-degree C. change in temperature for a number of developers.

Production of flexibility and the lessening of static in motion picture film has received much attention.[30] A non-static film is made by applying to it an electrolytic solution dissolved in cellulose ester solvent and drying the film. A film with high flexibility maintenance[31] is made by a composition including cellulose acetate and tributyrin.

Investigations of the effect of scratches and cuts upon the strength of motion picture film have been extended to processed film in different conditions.[32] Scratches were made on the film by drawing it at a constant rate under a point bearing a given load, and the effect of the scratch was determined both by measurement of the elastic curve and by folding tests. The investigation on the whole confirms previous conclusions as to the effect of scratches upon bare film support not coated with emulsion.

Further research has been carried on in the field of photographic chemicals. A patent has been granted[33] on a cellulose nitrate composition substantially free from camphor including cellulose nitrate, monochlornaphthalene, and a monohydroxy aliphatic alcohol containing from three to six carbon atoms such as butyl alcohol. An important method of manufacturing sodium thiosulfate[34] involving treating sodium carbonate with sulphur dioxide and gaseous sulphur has been developed.

Research has developed a method[35] by which inert gelatin for use in photographic emulsions is prepared by freeing wholly or partly ordinary gelatin from sensitizing compounds normally contained therein by treatment with an oxidizing agent.

While 16-mm. film has been definitely standardized in this country, a 17½-mm. width motion picture film has been designed in

[29] "Phot. Rund.," *62*, Nov., 1925, p. 428.

[30] U. S. Patent 1,570,062.

[31] U. S. Patent 1,572,232.

[32] "Trans." S. M. P. E., 24, p. 122 (Communication No. 251 Eastman Laboratories).

[33] U. S. Patent 1,580,189 (Eastman Kodak Company).

[34] U. S. Patent 1,570,253 (Grasselli Chemical Company).

[35] British Patent 245,456.

France[36] for a projected picture of 7 to 8 feet in width. The film is first cut to 35 mm. width and perforating, printing and processing are accomplished before the film is slit into two strips 17½ mm. wide. The picture frame is one-half the height of 35 mm. standard and the image space is sixty per cent greater in area than that of 16-mm. film. A 150-meter length of the film weighs 500 grams without a reel.

General

Considerable progress was made in Germany and abroad in the field of photographic and cinematographic technique[37] in 1925. News from Germany indicates the commercial practicability of a flexible glass.[38] A rod of ½ inch in thickness has been bent in a half circle without the aid of heat and it springs back to its original shape on being released. The Kipho Exposition at Berlin in 1925[39] was the first of its kind to be held there. In addition to trade exhibits, the historical evolution of photography and cinematography was illustrated. Many perforators and printers[40] were exhibited.

Illuminants

No marked innovations have occurred in the field of illuminants either for the taking or projecting of motion pictures. Constant minor improvements are being made upon incandescent and arc lamps.

An extensive treatment has been given to the geometrical optical problem in the design of the reflector arc lamp.[41] Curves, showing the magnitude of aberration in spherical, parabolic and elliptical reflectors when used either singly or in various combinations with condensing lenses, have been determined along with the advantages and disadvantages of these systems.

The American value of 700 candles per square millimeter of brightness of high intensity arcs is thought by a foreign writer to be greatly exaggerated.[42] The brightness of the crater of a German carbon at 200 amperes is given as 837 candles per square millimeter, with an average of 458 candles per square millimeter for the entire surface of the carbon.

[36] "Cinemat. Franç.," *8*, March, 27, 1926, p. 12.

[37] "Phot. Ind.," *24*, Jan. 11, 1926, p. 30.

[38] "Amer. Project.," April, 1926, p. 3.

[39] "Phot. Ind.," *23*, Oct. 5, 12, 19, 26, Nov., 2, 1925. pp. 1089, 1120, 1145, 1170, 1196.

[40] "Kinotechnik," *7*, Dec., 25, 1925, p. 618.

[41] "Trans." S. M. P. E., August 23, 1925, p. 94.

[42] "Compt. Rend.," *181*, Dec., 28, 1925, p. 1133.

Laboratory Equipment and Apparatus

A new developing unit has been devised[43] which eliminates breaks in a European continuous developing machine. The cemented splice is replaced by a metal staple, and a special splicing machine trims the film ends and holds the staple in place magnetically while the cover is being brought into position. From location of break to completion of repair only 15 seconds is required.

A new type of automatic monochromatic sensitometer for measuring the spectral distribution of sensitivity of photographic materials has been brought out,[44] the unique feature of which is a sector wheel in which the apertures are spaced spirally about the center of rotation. While this sector wheel rotates at a uniform angular velocity, it is moved longitudinally so that the spirally arranged apertures travel in the proper relation to the photographic material. A cam plate attached to the shaft carrying the sector disc actuates an electro-magnetic device which moves the photographic plate forward one step after exposure through the successive apertures. In this way twelve exposures increasing by consecutive powers of two are obtained.

In a paper read at the Washington meeting of the Society, an efficient film cleaning machine is described,[45] which very satisfactorily cleans and revitalizes dirty film.

Lenses

A new heat resisting condenser has been produced[46] which is impervious to changes of 350 degrees and more, it is said. This product is made from an optical heat resisting glass, known as Ignal glass, having a low coefficient of expansion, 0.000004 between 32 and 320 degrees F., (about ten times that of quartz).

By replacing silicon with germanium oxide an excellent glass known as Germanium glass has been obtained[47] which has a higher refractive index for the sodium lines and which is much more homogeneous than sodium glass.

An investigation has been made of the annealing and re-annealing

[43] Kinemat. "Weekly" (Sup.), *109*, March 18, 1926, p. 64.

[44] "J." Opt. Soc. Amer., *12*, April, 1926, p. 401, Communication No. 256 from Research Laboratory, Eastman Kodak Co.

[45] "Amer. Project.," July, 1926, p. 12 (Trans. S. M. P. E. No. 25, p. 117).

[46] "Amer. Cinemat.," Sept., 1926, p. 20.

[47] "J." Amer. Chem. Soc., *47*, July, 1925, p. 1945.

of glass[48] including the various types of strain. Several tables were formulated showing the amount of temporary strain remaining as permanent strain in slabs of different kinds and different thicknesses. The temperature of annealing, and the conditions for the total time of annealing and cooling to be a minimum, are considered, and the results applied to a particular case.

The U. S. Bureau of Standards has produced a new optical glass of surprizing clearness[49] free from the defects usually encountered. This discovery will probably be of great value to manufacturers of lenses both for photographic and projection purposes.

United States patents indicate some activity[50] in the field of wide aperture (F/1.7–1.5) lenses for 16-mm. film.

Motion Picture Applications

A rather unique and new application of motion pictures is found in the investigation of the movement of the heart by the use of a slit diaphragm and moving film,[51] and is effected by radiographing the heart on a film moving vertically, through a horizontal slit placed between the patient and the film.

Stop-motion picture photography has apparently not received much further impetus in this country. An article has been written giving a description[52] of the methods of making animated cine titles for stop-motion picture photography in advertising film.

Physiology

There has been an increasing use of colored motion pictures, and at least two of the first-quality films recently released are in color. The extent of eye strain in the viewing of motion pictures has long been a subject of contention. The Psychology Department of Harvard University has made a study of colored and ordinary motion pictures,[53] the result of which has shown that eye strain is much less for the average sensitive observer after seeing a colored picture. Vision experts of both America and England hold[54] that motion pictures do not injure the eyes when viewed under the proper projected

[48] "Trans." Opt. Soc., *26*, No. 1, 1924–25, p. 14.
[49] "Amer. Project.," April, 1926, p. 3.
[50] U. S. Patent 1,580,751.
[51] "J." Roent. Soc., *21*, Oct., 1925, p. 142.
[52] "Amer. Phot." *20*, Feb., 1926, p. 66.
[53] Cleveland "Times," Sept., 5, 1926.
[54] "Amer. Cinemat.," Sept., 1926, p. 6.

conditions. Eye strain is usually traceable to prolonged concentration of the eye, defective eye sight, position of the observer, faulty general illumination, poor films, bad projection, or faulty operation. All of these conditions, it is declared, are avoidable.

An interesting article has been written[55] on the subject of "Light Sense." The statement is made that when the eye becomes adapted to darkness, the form sense and color sense become inactive, and the order of disappearance is red, green, yellow and blue. Two measurements for light sense are described.

Physics

It has been found that bakelite 0.5 m n. thick transmits thirty per cent of wave length 313.3 $m\mu$. but is opaque below 275 $m\mu$., after a long exposure to daylight or exposure to a quartz mercury lamp.[56] A 2 mm. sample dyed with safranine showed characteristics similar to the Wratten red beta filter, but more of the extreme red is transmitted.

Projection Room Equipment and Apparatus

More uniform quality of projection is being attained by constant improvement and innovations in the projection room and projecting equipment. New inventions and developments are contributing to the goal of safe and uniform high quality projection and are making the value of a projected picture less dependent upon the skill of the individual operator.

In order to get most satisfactory results and naturalness of action upon the screen, the projector should be run at exactly the same speed as that at which the camera was operated when taking the pictures. As it does not seem possible at present to automatically synchronize projector and camera speeds, this can only be done by observing the projector speed which gives the best results for each scene, or by following a cue sheet furnished by the producer which gives the correct speed for each scene. In either case this can only be accomplished by using an accurate speed indicator. In a talk delivered before the Society on April 22,[57] a speed indicator was described consisting primarily of a magneto of light and compact construction, driven by the projector and generating a voltage directly proportional to its speed, connected to one or more voltmeter indicators

[55] S. M. P. E. "Bulletin," Aug., 1926.
[56] "Compt. rend.," 181, Nov., 23, 1925, p. 783.
[57] "Amer. Project.," April, 1926, p. 4 (Trans. S. M. P. E., 25).

calibrated in feet per minute and minutes per thousand feet of film speed.

A new film footage or running gauge has been developed[58] consisting of the take-up spool graduated in circles so that the footage coming through can be seen at a glance through the bars.

Projectors

No actual new developments in the field of projectors have appeared in the last few months. Technicians have been satisfied with directing their efforts along the lines of minor improvements upon existing equipments. Patent surveys indicate constant work upon continuous projectors, especially in foreign countries. However, no outstandingly new inventions have been achieved.

Foreign patents indicate extensive activity in the use of air blast cooling of film in projectors[59] and still further development in the control of the electrical circuit by air blast.

Screens

Some additional data have been published on the light reflection characteristics of screens.[60] If a surface of magnesium carbonate prepared in the laboratory is taken as one hundred per cent white, then the reflecting power of plaster, cloth and beaded surfaces are about 80, 60 and 78 per cent, respectively. The specially prepared specular screens which concentrate the reflected light along the axis may show a value of perhaps four hundred per cent when viewed normally.

Standardization

An International Congress was held at Paris[61] in July, 1925, on the standardization of motion picture machinery. The cooperation of our Society has been invited, and undoubtedly relations of benefit to all concerned will be established.

Statistics

A recent survey on the basis of September 1[62] indicates that there are 20,233 picture theaters in the country receiving approximately

[58] Kinemat. "Weekly," *110*, April 12, 1926, p. 75.

[59] German Patent 452,308.

[60] "Mov. Pict. World," *80*, May 8, 1926, p. 145.

[61] Kinemat. "Weekly," *108*, Feb. 11, 1926, p. 78.

[62] Cleveland "News," September 16, 1926. The "World Almanac," 1926, p. 30.

$1,000,000,000 yearly in admission fees. The average weekly attendance in 1925 was 90,000,000 persons. Two hundred and thirty-five million feet of film were exported from this country in 1925.

The value of imports of photographic materials into Great Britain and Ireland during 1925 was as follows:[63] cameras (without lenses), $891,491.12; sensitive paper, $622,052.90; plates and films, $3,662,870.22; motion picture film, raw stock, $1,732,764.96; motion picture positives, $1,137,011.58; motion picture negatives, $3,350,256.32.

Stereoscopic Pictures

Some progress has been realized in the field of plastic projection. Apparent relief has been obtained by projecting two colored images on a grid screen,[64] the bars being of one color and the background of another. The eye sees one picture when focused on the near bars with another dimly suggested in the distance.

Stereoscopic effects with multiple screens have been obtained[65] by means of the usual screen having a large central area cut away and replaced by green gauze. At the back of this, but some feet away, is placed a red curtain. A still picture is focused on the primary screen margin, and then motion pictures are projected on the gauze. The subject matter appears to stand out in living solidity in the window.

Studio Effects and Practice

Current literature reviews many methods of trick photography claimed to be new, most of which are quite old and long tried.

A method for the production of motion pictures in silhouette with the elimination of elaborate settings and scenery is exhibited[66] at a new theatre in Breslau, Germany. A mask is held in front of the camera lens to produce the scenery and the pictures perform in silhouette.

A new photographic process has been introduced[67] in which two negatives are filmed at once but which are combined into a single negative by means of which it is claimed studio shots may be incorporated with any background. English producers have recently found that compensation for the change in exposure due to varying

[63] "B. J.," *73*, March 5, 1926, p. 137.
[64] Kinemat. "Weekly" (Sup.), April 8, 1926, p. 57.
[65] Kinemat. "Weekly," *110*, April 22, 1926, p. 79.
[66] "Kinotech. Rund.," *62*, Nov., 1925, p. 83.
[67] "Amer. Cinemat.," August, 1926, p. 23.

the cranking speeds during the taking of trick scenes[68] is easily accomplished by changing the shutter sector while cranking. A fade-out attachment is also used.

The taking of talking motion pictures requires[69] a studio for the production of combined sound and picture film records having its walls, ceiling and floor covered with felt or other sound deadening material. The combined cinematographic camera and photographic sound recorder are located within a sound proof cabinet in the room.

Talking Motion Pictures

Talking motion picture films are now being produced in London under the De Forest patents.[70] Great improvement in sound rendering has been secured with the use of an image of the light slit focussed by a microscope objective instead of by the slit itself.

[68] "Kinotechnik," *7*, Dec., 25, 1925, p. 628.
[69] British Patent 245,321.
[70] "Bioscope" (Sup.), *66*, Jan. 28, 1926. p. IV.

REPORT OF STANDARDS AND NOMENCLATURE COMMITTEE

A REPORT was prepared for presentation at the Spring Meeting but on account of not having a quorum of voting members present when the report was called for, it was deferred until the Fall Meeting. The following is a report for the Spring and Fall Meeting:

You will recall that at the Fall Meeting, 1925, final action was taken by this Society on all matters presented by this Committee, with the exception of film splices, film sprockets and camera cores. We will, therefore, deal with these three subjects:

Film Splices

At the Spring Meeting, 1922, the subject of film splices was presented by Mr. McNabb of the Bell and Howell Company; and at

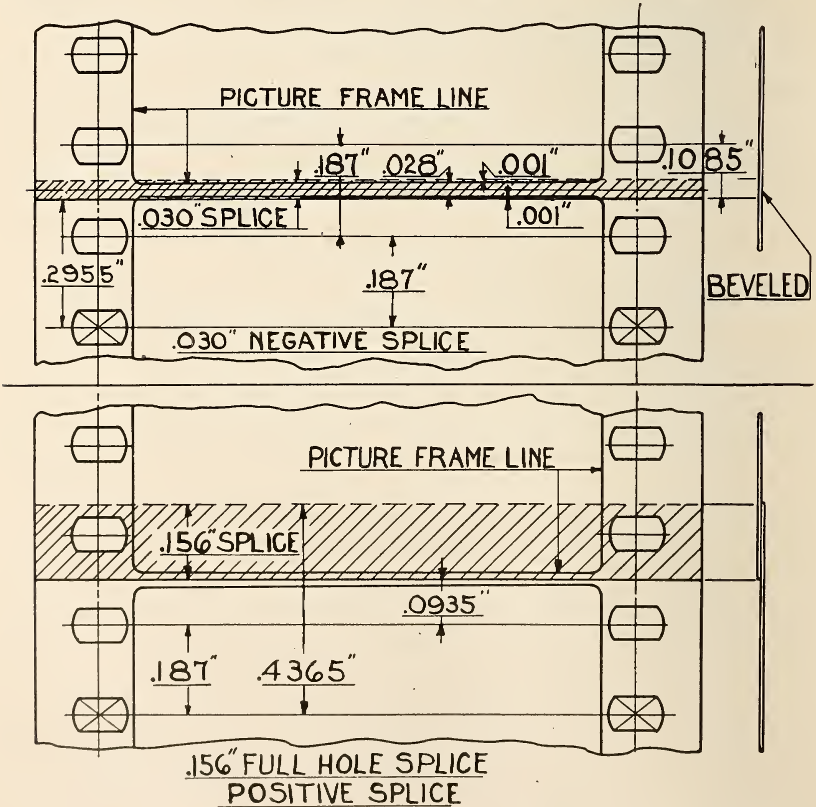

Fig. 1

the Spring Meeting, 1924, a request was made that this Committee consider standardizing the width of film splices for exchanges and theatres.

Recommendations were made at the Spring Meeting, 1925, but, on account of receiving a telegram from Mr. Earl Denison to the effect that he wished to do further research work on film splicing, this matter was held in abeyance and referred back to the Committee.

At the Fall Meeting, 1925, the Committee recommended that the width of film splices be standardized as given at the Spring Meeting, but owing to certain points brought out in the discussion of Mr. Earl Denison's paper given at a previous session, the Committee asked that this matter be referred back to them for further consideration.

As a result of further investigation and research work carried on by Dr. Sheppard, of the Eastman Kodak Company, we now recommend adoption as standard, splices made according to the dimensions in Fig. 1 for laboratories and exchanges.

(*Motion Duly Passed to Adopt Recommendation*)

Film Sprockets

You will recall that at the Fall Meeting, 1925, Mr. Porter gave the dimensions of film sprockets as proposed by the Paris Congress, and after some discussion as to what action should be taken by this Society, the matter was referred back to the Committee.

Since that time we have received communications from M. L. Lobel, Secretary of the Paris Congress and President of the Cinematograph Section of the French Photographic Society; and Mr. W. Vinten, President of the Incorporated Association of Kinematograph Manufacturers, Ltd., London, in connection with the standards proposed at the Paris Congress. Up to the present time, agreement has not been reached. The recommendations of this Committee are now receiving their consideration—we having sent them our objections to dimensions proposed.

As you will recall there was a paper given at Ottawa at the Fall Meeting, 1923, on film sprocket design which covers about twenty pages in the Transactions, so that you can appreciate considerable work has been done on this subject which enables this Committee to make recommendations to this body for your consideration. In order to do this, we have prepared five figures, which were made from charts sent to M. Lobel and Mr. Vinten.

Fig. 2 represents a condition with freshly developed film. You will note at the intermittent sprocket that the film is in theoretical contact with the teeth from "A" to "B", that is, four teeth are engaged. On the takeup sprocket you will note that the film is held by the leaving tooth "D" and as the film is practically of normal pitch you will note a slight clearance at "C", so that the film is held against the rewind tension by tooth "D". As the film leaves the sprocket at "D" it will be engaged by the next tooth. As there is no resistance of the film to be fed forward by the sprocket, the film will cam off the leaving tooth and creep so that the next tooth is engaged.

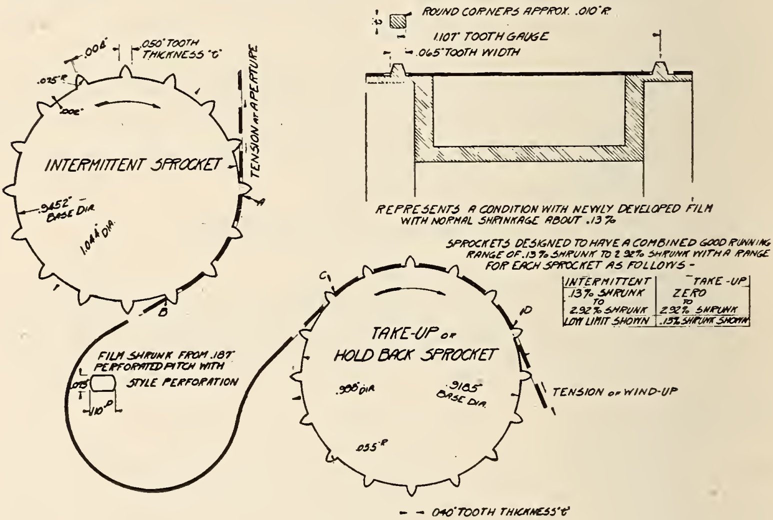

Fig. 2.

Referring to Fig. 3, the condition as shown represents film when shrunk about 1.5%, and referring to the intermittent sprocket you will note that the film is engaged by tooth "B", and as the film cams off the tooth "B" it is engaged by the next tooth. The advantage of the film being pulled by the leaving tooth is on account of the snubbing action between the film and base diameter of the sprocket. You will note that the film at "D" of the takeup sprocket is engaged, and there is increased clearance at "C", there being no interference at the entering tooth.

Referring to Fig. 4, this represents a condition of film with 2.92% shrinkage. You will note that the film is being moved by the leaving tooth "B", the film having shrunk to the extent that interference is just starting at "A" the entering tooth, and represents the maximum shrinkage that can be run on a sprocket of this design without interference. You will note that the film is still engaged at tooth "D" of the takeup sprocket and that there is no clearance on the opposite side of the tooth at "C", showing that the film has the maximum shrinkage that can be run on a sprocket of this design without interference at the entering tooth.

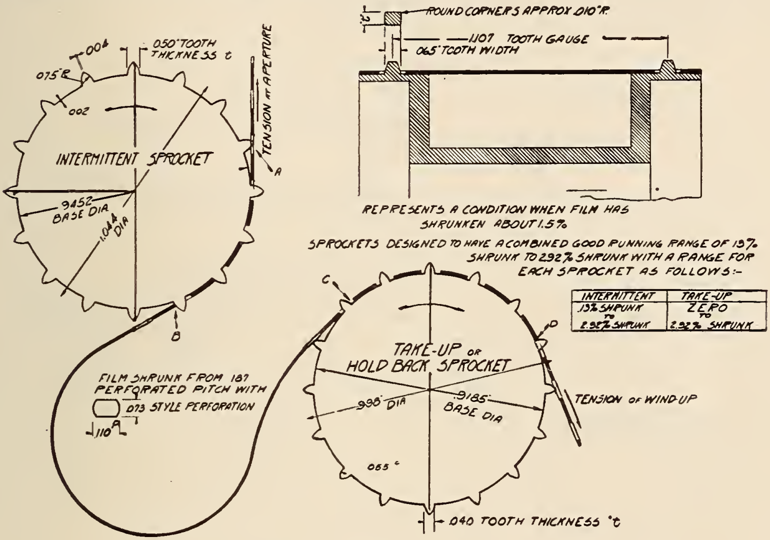

Fig. 3.

The sprockets shown on these three charts all have the same dimensions for each style of sprocket; the base diameter for the intermittent sprocket is 0.9452″ and the base diameter for the takeup sprocket 0.9185″. They are designed for four tooth engagement on the intermittent and six teeth engaged on the takeup, this being the predominating condition on projectors in this country. The condition shown in Fig. 3, represents a mean between the conditions shown in Figs. 2 and 4 and the relation of the film perforations with the sprocket teeth will vary within that range according to the different degrees of shrinkage.

It is obvious that the base diameter changes according to the number of teeth engaged if the range of shrinkage is to be constant. With a fewer number of teeth engaged it is obvious that the thickness of the teeth can be increased, and likewise with a greater number of teeth engaged the thickness of the teeth will have to be reduced, depending upon the range of shrinkage for which the sprockets are designed.

The transverse dimensions of the sprockets can be uniform, also the width of teeth. We have not shown any tolerance on these dimensions, but we feel that 0.0005″ plus or minus would not work any great hardship on the manufacturer, but any increase of tolerance would interfere with running conditions.

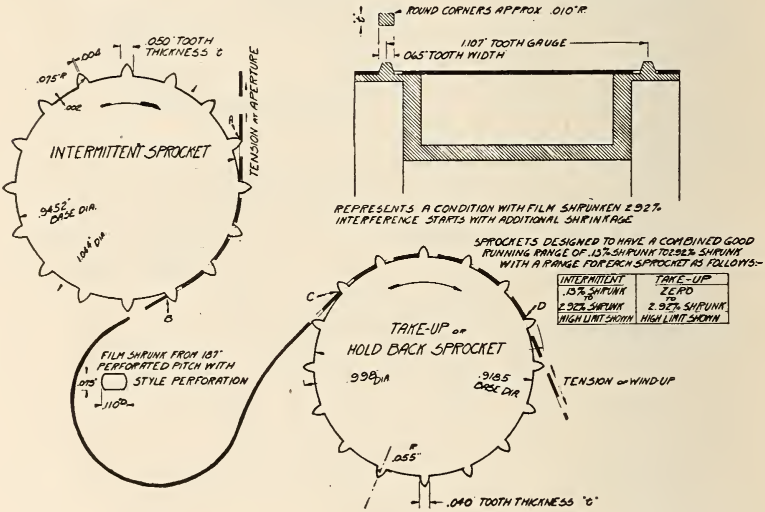

Fig. 4.

We have noticed that considerable damage is done to the film by crowding it on to the takeup sprocket, that is, the film is forced over the entering tooth. According to these charts you will note that this condition is overcome. On the intermittent sprocket the greatest damage is done when the pitch of the film is enough less than the pitch of the sprocket so that the entering tooth is forced into the perforation at "A" as shown in Fig. 4, there being no clearance at the leaving tooth at "B".

We have had Figs. 5 and 6 prepared in order to represent conditions with sprockets having the base diameter as proposed by the Paris Congress.

Referring to the intermittent sprocket in Fig. 5, you will note that the film is moved forward by the entering tooth, the film being of normal shrinkage, approximately 0.13%. This condition of the film being moved forward by the entering tooth will be maintained until the film has shrunk 0.78% which is the normal pitch of the sprocket and theoretically four teeth will engage the edge of the perforations, but with additional shrinkage of the film the condition will change so that film is moved forward by the leaving tooth "B" which will continue until the film has shrunk 2.89% which will be the maximum shrinkage film can have and run on this sprocket

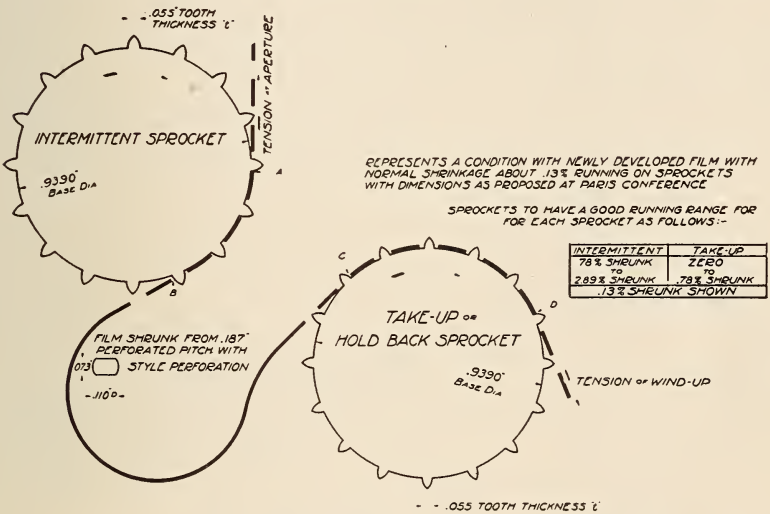

FIG. 5.

without interference on the entering tooth. What we want to avoid is the film being fed forward by the entering tooth and with this design of sprocket this condition will exist until film has shrunk 0.78%, so that the range of good running condition is between a shrinkage of 0.78% and 2.89%.

Referring to the takeup sprocket you will note that the film is held against the rewind tension by the leaving tooth "D" and there is clearance at the entering tooth "C", this being a good running condition and one that will be maintained until the film has shrunk to 0.78%. After film has shrunk in excess of 0.78% the film will be held against the entering tooth "C". What we want to avoid is film being held against the rewind tension by the entering tooth.

Referring to Fig. 6, the intermittent sprocket represents a condition with film shrunk to 2.92%. You will note that the leaving tooth is engaged at "B" and the entering tooth is interfering at tooth "A". Referring to the takeup sprocket, Fig. 2 represents an exaggerated condition as to the tendency of the film to climb the sprocket when the film has shrunk so that the pitch of the sprocket is greater than the pitch of the film, that is, the film according to our calculations with this size sprocket, when shrunk in excess of 2.23% would tend to climb the entering tooth.

While the dimensions of sprockets shown in Fig. 2 will run film from zero to 2.92% shrinkage, film having this excessive shrinkage would rarely be used. As there is nothing sacrificed in allowing for this excessive shrinkage, we thought best to do so, as the base diameter allows the pitch of the tooth to be approximately the same as the pitch of the perforations with freshly developed film. The allowance for shrinkage is determined by the thickness of the teeth so that we have a good running condition when the film is first run. This is very important as it appears that the greatest damage is done during the first projection.

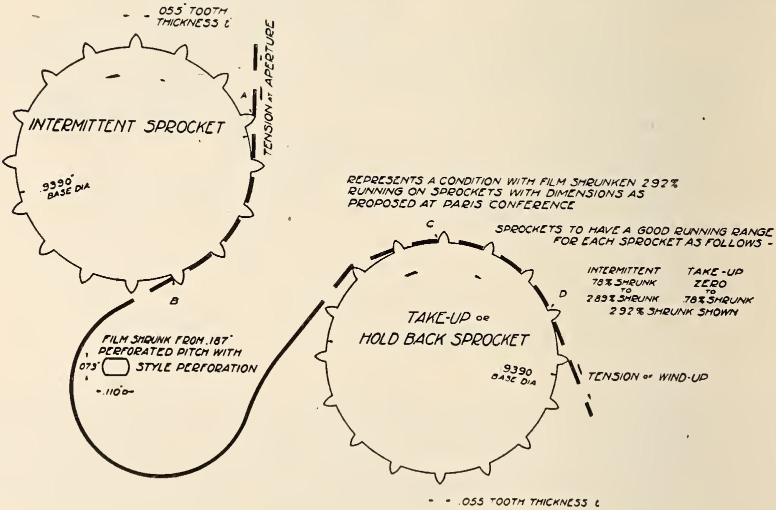

Fig. 6

The dimensions for intermittent and feed sprockets can be the same. Takeup sprockets should differ slightly from the feed sprockets as the conditions under which they function are different.

Camera Cores

At the Fall Meeting, 1925, the question was again referred to the Committee as to standardizing the dimensions of camera cores. It was recommended at the Paris Congress that the external diameter be 50 mm. which is 1–31/32″, and the internal diameter be 20 mm. or approximately 25/32″.

Mr. Porter brought this matter to your attention at the Fall Meeting, 1925. The matter was referred to this Committee for further investigation and before coming to any definite decision it will be necessary to get more data from the manufacturers of cameras, getting, if possible, the approximate number of cameras of each kind in use, together with the size of cores used at present, so that in standardizing the size of cores, the dimensions should be chosen to cause the least confusion and waste.

For example, information we have from one manufacturer of cameras states that at the present time they are using a core 1–7/8″ outside diameter and 1″ inside diameter, they having used this size for the past fifteen years; and that there are 800 of the cameras in use, together with 4,000 magazines and 10,000 cores. These are in use in this country and abroad, so that if we should use the same dimensions as proposed at the Paris Congress, all the cores in the magazines of these cameras would have to be changed in order to become standard. So, we believe we should not be too hasty in making definite recommendations.

Respectfully submitted,

L. C. Porter
F. H. Richardson
H. P. Gage
C. M. Williamson
C. A. Ziebarth
H. Griffin
J. G. Jones
Chairman

DISCUSSION

Pres. Cook: Are these the same dimensions as recommended by the foreign people?

Mr. John G. Jones: The dimensions shown are not the same as recommended at the Paris Conference.

Dr. Mees: May we ask for a statement as to what are the objections made by the foreign societies before we adopt this?

Mr. Griffin: We have done, as I think Mr. Jones knows, quite a good deal of worrying about sprockets. Simplex and Powers were working separately on it before the consolidation and we are working still. I do not know how the figures were arrived at by the Rochester men, but we requested the co-operation of the Famous Players people through Mr. Palmer, and they let us have about a hundred pieces of film thirty inches long from releases over a period of five years which had run on projectors during that period continually. Mr. Dina, chief engineer of our company, checked up these films for maximum, mean, and minimum shrinkages, and his figures do not agree, particularly on the take-up, with the dimensions given by the Eastman Kodak Company, and I hesitate therefore to vote the thing into use until we have done more research work on it; it is a problem which needs more consideration, I am sure, before we can adopt a standard. It is not a matter of only one machine. Projectors differ considerably in the number of teeth engaged on the take-up sprocket and sometimes there is interference.

Mr. John G. Jones: These dimensions are based on the number of teeth engaged. In designing sprockets, the number of teeth engaged and also the range of shrinkage should be considered. The greatest damage to perforations is caused by the intermittent sprocket.

Pres. Cook: May the Chair inquire if the intermittent sprocket is different from the foreign?

Mr. John G. Jones: Yes, it is.

Pres. Cook: Does Mr. Griffin agree with the dimensions of the intermittent sprocket as recommended by the Committee?

Mr. Griffin: Yes; the upper sprocket is the same as the intermittent.

Dr. Mees: Apparently what Mr. Griffin's company did was to measure the film, while the Committee depends upon the film being standard. Will Mr. Jones tell us how the Committee arrived at their film standard?

Mr. John G. Jones: We made a great many wear and tear tests of films having different degrees of shrinkage from zero up to what we believed would be the maximum shrinkage to be encountered, and found that a sprocket of these dimensions (indicating) gave the best results.

Mr. Kelley: Were all the tests designed to make use of the Bell & Howell or Eastman standard?

Mr. John G. Jones: Tests were made using Bell & Howell standard perforations (indicating) as we considered this was the worst condition. Films with rectangular perforations, round cornered, were also used which gave still better wear and tear results.

Mr. Griffin: There is a peculiar thing which came up recently. We are making a great many tests. Some one came from the Technicolor Company the other day and said: "We don't know what is the matter with the Simplex projector." We looked at the film, and to all appearances the film had increased in length rather than shrunk, and we don't know the cause of this, although we think it is due to imperfect perforation because it is not usual for film to stretch.

Mr. John G. Jones: We have had samples of film where the pitch is in excess of the standard due to film being wound on drying drums and dried in a stretched condition. The increase in pitch due to stretch would not be enough to interfere.

Dr. Mees: I don't know of what age Mr. Griffin's film was, but the film standard perforation has been changed not in pitch but in form. The present film which is standard in all countries now has the new square perforation with rounded corners. Any new sprocket designed should be set for the new film.

Mr. Griffin: I think this is important enough to lay over.

Dr. Hickman: I suggest that this is a matter for experts, and the conclusions should be adopted en bloc, or if a popular vote must be taken we should be given an opportunity of studying the report. Most of us present do not know what we are voting for. Either we should give the Committee the power to do the whole thing or they should circulate a printed report before it goes to vote.

Dr. Mees: I think it would be advantageous from an international point of view for the thing to be suspended rather than make a judgment on it as it stands. I move that the matter be referred back until the next meeting.

(*Standard on film sprockets thereupon by vote referred back to Committee.*)

REMARKS ON THE STANDARDIZATION OF MOTION PICTURE SPROCKETS

H. JOACHIM *

Translated from "Science et Industries Photographiques," October 1, 1926 by C. E. K. Mees.

ONE of the most difficult questions for the motion picture engineer is that of the dimensions of sprockets. An incorrectly sized sprocket produces in most cases rapid destruction of the film. For this reason committees on standards in various countries have worked on the dimensions of films and of sprockets. A definite international agreement would be of great value both for the manufacturers and for the users of motion picture apparatus. This question was discussed at length at the International Congress of Photography held last year in Paris, and the details of the discussion have been published in the Comptes rendus of the Congress. The decisions which are of especial interest to us from the point of view that we propose to discuss are those relative to the pitch of the film, to the height of the perforations, and to the maximum shrinkage allowed. A pitch of 4.75 mm. has been adopted, a height of the perforation of 2 mm., and a shrinkage of 1.5%. No opposition having been offered to these dimensions, we may consider them in future as the standard dimensions accepted officially.

We shall then be justified in requiring in future from the makers of apparatus that the perforations of film, used in machines that they give us, shall be damaged to only a minimum degree. This problem would be easy to solve working on known principles used in the construction of racks and pinions if the film had a rigidity comparable with that of a rack. Unhappily for many reasons, this is not the case: first, because of the shrinkage which shortens the films and because of the formation of a buckle before and after the pull down sprocket, and lastly because the perforation is easily torn when the teeth enter and leave it.

A pull down sprocket acts as is shown in Fig. 1. The film touches the sprocket only over a part of its circumference; on the portion in contact with the sprocket, a certain number of teeth enter the

This paper was not read at the meeting, but is deemed of sufficient importance to warrant inclusion in the Transactions.

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FIG. 1

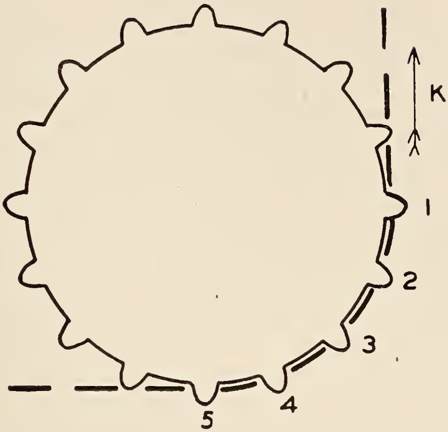
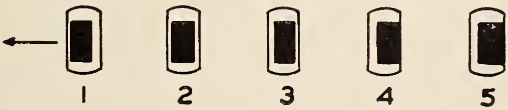


FIG. 2

FIG. 3

FIG. 4



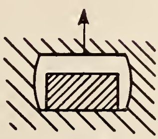


FIG. 5

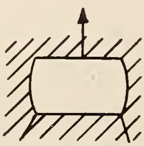


FIG. 6

bottom of the perforations. In the front portion of the film the teeth enter and in the rear they leave it. We must also distinguish, in film operated by a sprocket, between the portion under stress and that which is not under tension. That under stress is that which is in contact with the pull down, or which meets with a resistance coming from friction in the track, or from the weight of the roll that the sprocket is pulling from. In the first case we have an idler sprocket, and in the second a pull down sprocket.

When the pull is in the direction of the arrow *K* in Fig. 1, the film touches only the back edges of the teeth *1–5*. The film is not in contact with the front edges, for the teeth are smaller than the perforations. The words "front" and "back" must be understood in the direction of the movement. The sections of the teeth of the sprocket may be shown as in Fig. 2, where the teeth are shown inside the perforations of the film. When the pull is made from the left side, the right side of the perforations are in contact with the teeth. In the case represented by Fig. 2, the position of the five teeth in contact is exactly the same; that is, each of the teeth is in contact with the right side of the corresponding perforation, but this case is a special one occurring only when the pitch of the sprocket is identical with that of the film.

We will term a sprocket normal relatively to a given film when it is of the same pitch as the film and vice versa. A normal film in regard to a given sprocket is that which has the same pitch as the sprocket. If we consider a film that is stretched; that is, a film of pitch greater than the sprocket, the conditions of the pull down are shown in Fig. 3. Tooth *5* is no longer in contact with the edge of the corresponding perforation and the same thing is produced to a corresponding degree for tooth *4* and those which follow it. Only tooth *1* bears on the film, and in this case the tooth and the perforations are subjected to a strain five times greater than is the case in Fig. 2.

If we now consider a shrunken film, that is a film of which the pitch is less than that of the normal film, we see in Fig. 4 that the first perforation is no longer in contact with the tooth. There is a space between the film and the tooth, a space which diminishes up to perforation *5*, this perforation being the only one which bears with its following edge on the corresponding tooth exactly like perforation *5* in Fig. 2. Just as before, perforation *5* and the corresponding tooth are under a strain five times greater than is the case in Fig. 2.

It follows from these results that when a film is in contact with a sprocket, only one pair of teeth bear—either the front pair, as in Fig. 3, or the rear pair, as in Fig. 4, according to whether the sprocket is smaller or greater than the normal sprocket corresponding to the film. The intermediate teeth do not play any part.

The pitch of a film being essentially variable as a result of shrinkage, the cases shown in Figs. 3 and 4 are the general rule, while that shown in Fig. 2 must be considered an exception. Pull downs will thus always be made by a single pair of teeth. If this is true theoretically it nevertheless seems logical to admit that in practice it will be produced only when there is a very great difference between the pitch of the sprocket and that of the film. In reality the edge of the perforation will yield a little as already shown in *5*, and we shall have more of the teeth in contact as the difference of pitch is smaller. On the other hand, it will be seen that when the difference of pitch is sufficiently great and the pull on the teeth is heavy enough, there will be produced an excessive pull which will produce damage to the corners as is represented in Fig. 6. The life of the film will thus be shortened. The damage will always be produced on the side of the perforation which is opposite to the tension.

In order to diminish this damage, we should make it a general rule that for a given film the pull down sprocket shall have a diameter somewhat smaller than that of the normal sprocket calculated for the film.

However, the same alterations can be produced also on the side on which there is no pull; that is to say on the side where the edge is without strain. In films pulled down intermittently, there is produced on the unstrained side a kind of vibration. The perforations no longer enter normally or go out normally and the film undergoes in relation to the teeth a vibrating movement which results in the mutilation of the perforations.

In Figs. 3 and 4 the portion not under tension is on the right, and from what we have said above in the case of Fig. 3, this section which tends to buckle will not suffer any damage. The tooth *5* will enter freely into the corresponding perforation. On the other hand, in the case of Fig. 5, one of the sides of *4* will come in contact with the sides of the perforation and the vibratory movement of the buckled section will damage the film. In order to diminish as much as possible the risk of damage to the film on the side where there is no tension, it is necessary that for a given film, the diameter of the operating sprocket should be smaller than the diameter of the normal sprocket corresponding to that film, see Table I.

In this table we have indicated the diameters of normal sprockets for films of which the shrinkage is from 0 to 2%.

In Column 5 are given the percentages of error in comparison with the German standard. The sprockets which fall within the tolerance limits approved by the Congress are surrounded by a thick dark line.

For unshrunken films, the diameter of the normal 16 tooth sprocket is 24.04 mm. In this case all the teeth will be in mesh. If one employs the same sprocket for a shrunken film only the last pair of teeth will bear, Fig. 4, and the strain on the perforation will be the greater the more shrinkage has occurred. Such a sprocket, then, will damage the films on the unstrained or buckled side.

For films having the maximum of shrinkage, 2%, the diameter of the standard sprocket is 23.56 mm. With unshrunken films or those which are only slightly shrunk, the first pair of teeth will bear and the strain will be greater as the film is longer. It is then new film which is in danger of being damaged by the forward teeth.

If the construction of a toothed sprocket is studied, it is customary to calibrate it so as to be best for new films. It is of less importance if very old films are somewhat damaged as long as new films are not damaged at all. From what has been said above, it will be seen that it is necessary to compromise between the sprockets which are correct for new fims and those for old.

Sprockets constructed according to the present German standard have for 16 teeth a diameter of 23.81 ± 0.02 mm. According to Table I such a sprocket would be normal for films with a shrinkage from 0.9 to 1.0%. If the maximum shrinkage is taken as 2%, the German sprocket may be considered to have been chosen for films of average shrinkage. Films with a shrinkage from 0 to 1% run perfectly on these sprockets and bear on the first pair of teeth, Fig. 3. Old films will bear on the last pair of teeth, Fig. 4, but if the shrinkage is greater than 1%, the films will not run so well on the German sprocket.

According to the standard dimensions accepted at Paris in June 1925, the diameter of sprockets should be 23.85 ± 0.05 mm. Such a sprocket can be termed "normal" for films with a shrinkage of about 0.8% or with the tolerances allowed for those shrunk from 0.6 to 1%. If we take the maximum shrinkage accepted at Paris as that of

1.5% the Congress sprocket will be normal for films of average shrinkage. As long as the shrinkage is less than 0.8%, this sprocket operates very well; above that it involves danger to the perforations. It will be seen that it is the maximum shrinkage which settles the size of the sprocket. If one can assume that in future the shrinkage of films will be less than 1.5%, a sprocket of 23.85 mm. will be better than that of 23.80 mm., for new films will run better on the larger sprocket. If one cannot limit shrinkage to 1.5% and, if as hitherto we must assume a shrinkage of 2%, the 21.85 mm. sprocket will be disadvantageous. Films of which the shrinkage exceeds 0.8% will run badly and the damage to the film will be increased as the shrinkage increases.

The sprocket accepted at the Congress of Paris differs from the German standard sprocket by the fact that it favors films with a shrinkage of less than 0.8% to the detriment of films which have a greater shrinkage. This suggests that it would perhaps be valuable to have apparatus with interchangeable sprockets so that it would be possible to work under the best possible conditions for both new and old films.

If the size of the sprockets is increased above that of the Congress standard, it will be to the detriment of old films. As in practice we have to deal with films of all kinds, it does not seem to us desirable to increase the diameter, so that the maximum shrinkage should be taken as less than 1.5%.

In the above considerations we have considered only sprockets with 16 teeth, and the same rules will govern the manufacture of sprockets of 32 teeth, and their diameters can be calculated from the results given in Table I. According to the standard of the Congress, a sprocket of 32 teeth would have a diameter of 47.85 ± 1.1 mm. However, when we use sprockets with 32 teeth, we must consider another factor—that of the number of teeth in mesh.

For a film to fit well on a toothed sprocket, it is necessary that the angle included should be sufficiently great. In Fig. 7 are shown two films; the solid line *1–1* includes an angle of 45°, while the film *2–2* shown as a dashed line has an angle of 135°. We know from experience that when a film bears on only a small portion of the periphery, the teeth throw the film off the sprocket very easily; on the other hand, film such as *2–2* in Fig. 7 is held on the sprocket even without the assistance of pressure rollers. In addition, it will easily be understood that with a film working under these conditions the support and the perforations are less strained.

With 16 teeth sprockets we were satisfied formerly with three or at most four teeth in mesh. At the present time we require six teeth in mesh, which corresponds to a contact angle of 135° like that of film *2–2* in Fig. 7.

FIG. 7

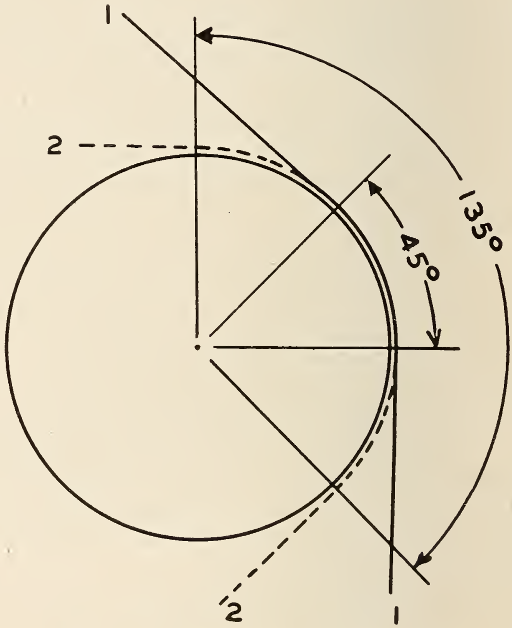


FIG. 8

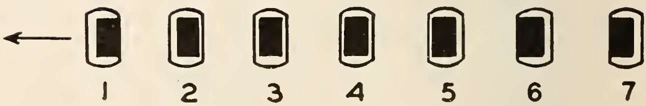


FIG. 9

With 32 teeth sprockets, if we wish to include a sufficient contact angle, some difficulties arise in consequence of the too great number of teeth in mesh. The phenomena which are shown can be followed with the aid of Figs. 2–4.

If we are concerned with a normal sprocket of which the pitch is equal to that of the film, each tooth is placed in the same position in relation to the perforation, and the number of teeth in mesh can be anything whatever. On the other hand, if we are dealing with a case similar to that in Fig. 3, we see that the following will happen: Tooth *1* is in contact with the back edge of the corresponding perforation, and a little interval exists in perforation *2* which increases in perforation *3*. The further we go to the right, the more the teeth are displaced towards the left in relation to the perforation. If the number of teeth are sufficient, the teeth will come in contact with the front edge of the perforation.

In Fig. 4 we have the inverse case. In the case of perforation *5*, the back edge of the tooth is in contact with the back edge of the perforation. The contact diminishes as we go from *5* towards *1*. If we continued this diagram beyond tooth *1*, we should arrive at last at a contact of the front edge of the tooth with the front edge of the perforation. If we wish to make more teeth enter the film, the teeth would tear the perforations. *From this we see that to have perfect contact the number of teeth in mesh must not be above a certain maximum.* Thus, in Figs. 8 and 9 we see that the teeth in mesh cannot be more than seven. If we try to use one tooth more, we shall seriously damage either the front or back edge of a perforation.

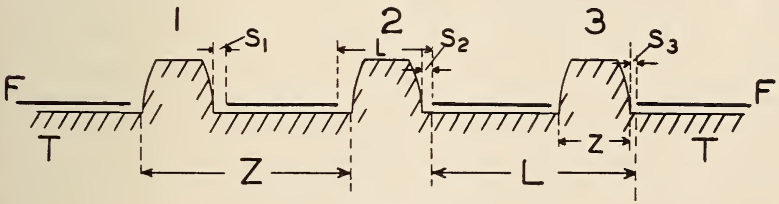


Fig. 10.

To go a little further into this question, let us calculate what can be the maximum number of teeth in mesh. There is shown in Fig. 10 a sprocket with sections of teeth *1*, *2*, *3* · · · and a film in contact with the sprocket. Let us call the thickness at the bottom of the teeth z and l the diameter of the perforations. Let us designate by s_1, s_2, s_3 the interval between the back edge of each perforation and the corresponding tooth. The pitch of the teeth on the sprocket will be designated by Z and that of the perforations by L.

We can write:

$$s_2 - s_1 = L - Z, \qquad s_3 - s_2 = L - Z$$
$$s_n - s_{n-1} = L - Z$$

from which we see that

(1) $$s_n - s_1 = (n-1)(L-Z)$$

an equation in which n signifies the number of teeth in mesh. As

(2) $$s_n - s_1 = l - z$$

(3) $$l - z = (n-1)(L-Z)$$

On the other hand, for a film which shows more or less shrinkage, we have

(4) $$L/l = v$$

which is a constant equal to the ratio between the pitch and the diameter of the perforation. We can write:

(5) $$(L/v) - z = (n-1)(L-Z)$$

If we designate by λ hundredths the error between the pitch of the perforations and the pitch of the teeth, we have

(6) $$L = Z(1+\lambda/100)$$

and substituting this value in (5),

$$Z/v(1+\lambda/100) - z = (n-1)Z\lambda/100$$

$$1 + (\lambda/100) - (vz/Z) = v(n-1)\lambda/100$$

(7) $$100 + \lambda - v(n-1)\lambda = 100vz/Z$$

z/Z is the ratio between the thickness of the teeth and the pitch of the sprocket. For a sprocket of 16 or 32 teeth we find in Table 1 the pitch corresponding to each diameter. For each thickness of the tooth z we can then calculate the ratio z/Z as a function of the diameter of the sprocket. The upper part of the curve shown in Fig. 11 gives the result of this calculation. The horizontal lines correspond to the diameters of the sprocket (from 24.04 to 23.56 mm. for 16 teeth and from 48.23 to 47.27 mm. for 32 teeth). On the right side we have shown the corresponding pitches from 4.75 to 4.65 and the corresponding percentage of shrinkage. For each thickness of tooth from 1.2 to 1.5 mm. the ratio z/Z is shown on the abscissa.

In the lower part of the curve is shown the calculation resulting from the application of equation (7). For each difference of $\lambda\%$ between the pitch L of the perforations and the pitch Z of the teeth are shown the maximum number of teeth for a given value of the ratio z/Z. This calculation has been made for a height of perforation of 2 mm. in accordance with the decisions of the Congress. From all this can be drawn the following conclusions:

The thickness of the teeth according to the decisions of the Congress is 1.40 ± 0.05 mm. The most disadvantageous value of the ratio z/Z is thus 0.31 for a tooth thickness of 1.45 and for the minimum diameter of the sprocket. Let us use, then, the vertical 0.31 on the curve. If we take the Congress sprocket of 23.85, the corresponding shrinkage according to Table 1 is 0.8%. For the maximum shrinkage of 1.5% the difference in relation to the film which is normal for the sprocket is thus about 0.8%. The intersection of the straight line $\lambda = 0.8$ with the vertical $z/Z = 0.31$ shown as a dashed line in Fig. 11 is seen to be at the horizontal level $n = 15$. The maximum number of teeth which can then be in mesh is fifteen.

Another example: if we take the minimum diameter of the sprocket which corresponds to a shrinkage of 1%, we have a difference $\lambda = 1\%$ between the pitch of the sprocket and that of the film. For a thickness of tooth of 1.45 mm., we have twelve teeth in mesh.

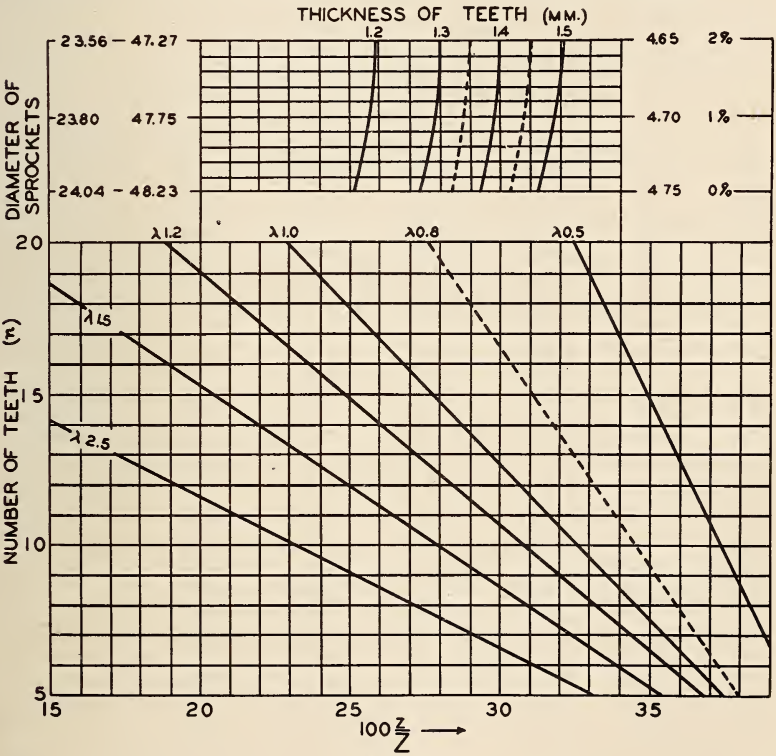


FIG. 11.

On the other hand, we could use a tooth of minimum thickness, 1.35 mm., with a sprocket of 23.85 corresponding to a shrinkage of 0.8% with a fresh film. In such a case the curve indicates eighteen teeth in mesh.

We may thus conclude from these examples that, *following the decisions of the Congress, we can have with the accepted diameters of* *sprocket in the most favorable case eighteen teeth in mesh and in the most unfavorable case twelve teeth.*

The limitation of the number of teeth in mesh agreed on by the Congress is thus not necessary. For sixteen tooth sprockets this limitation may be useful, but it is disadvantageous for thirty-two tooth sprockets.

TABLE I

DIAMETERS OF SPROCKETS ADAPTED FOR SHRUNKEN FILM

% shrinkage	Pitch of perforations (mm.)	Diameters of sprockets		% Deviation from standard dimensions		Remarks
		16 teeth	32 teeth	1925 Congress.	German	
0	4.750	24.04	48.23	0.8	0.9	New Film
0.1	4.745	24.02	48.18	0.7	0.8	
0.2	4.740	23.99	48.13	0.6	0.7	
0.3	4.736	23.97	48.09	0.5	0.6	
0.4	4.731	23.94	48.04	0.4	0.5	
0.5	4.726	23.92	47.99	0.3	0.4	
0.6	4.721	23.90	47.94	0.2	0.3	
0.7	4.717	23.87	47.89	0.1	0.2	
0.8	4.712	23.85	47.85	0.0	0.1	Paris 1925
0.9	4.707	23.82	47.80	0.1	0.0	German
1.0	4.702	23.80	47.75	0.2	0.0	Standard
1.1	4.698	23.78	47.70	0.3	0.1	
1.2	4.693	23.75	47.65	0.4	0.2	
1.3	4.688	23.73	47.61	0.5	0.3	
1.4	4.683	23.70	47.56	0.6	0.4	
1.5	4.679	23.68	47.51	0.7	0.5	
1.6	4.674	23.66	47.46	0.8	0.6	
1.7	4.669	23.63	47.41	0.9	0.7	
1.8	4.664	23.61	47.37	1.0	0.8	
1.9	4.660	23.58	47.32	1.1	0.9	Old Film
2.0	4.655	23.56	47.27	1.2	1.0	

With six teeth in mesh the film is in contact with the sprocket only over 67.5°. This is distinctly insufficient, and we have seen that it is possible while still accepting the decisions of the Congress to bring into mesh a larger number of teeth. Sprockets with thirty-two teeth being frequently used in projectors and other apparatus, we do not see why a maximum of six teeth should be maintained in view of the fact that when the number of teeth in mesh is increased the wear on the film decreases. This limitation was necessary with the old German standards. It may even be asked if it would not be useful in order in certain cases to increase the number of teeth in mesh to reduce the thickness of the teeth to 1.3 or even 1.2 mm. From the technical point of view this practice should not cause any objection for the wear on the teeth is inversely proportional to the number of teeth in mesh.

From the above considerations it will be seen that sixteen tooth and thirty-two tooth sprockets cannot be discussed in exactly the same way. It is not possible always to pass from one to the other simply by a proportional modification of the diameter. Thus, for instance, if we take a sprocket of 23.99 mm., a size frequently used formerly, this will be satisfactory although there will be a little strain, with films with 2% shrinkage. The normal film for this sprocket is one with a shrinkage of 0.2%. With a film with 2% shrinkage and teeth of 1.4 mm., only eight teeth can be in mesh. A thirty-two tooth sprocket of corresponding size will be unusable with most apparatus for twelve teeth cannot be put in mesh with it. On the other hand, on the small sprocket six teeth can be put into mesh perfectly.

"TECHNICAL ADVANCE"

MARTIN J. QUIGLEY*

IT HAS frequently appeared to me that the obligation of the motion picture industry to its technicians is not properly or proportionately recognized. It seems to be common practice to lavish almost inordinate praise and compliment upon practically every other factor responsible for a great motion picture, but the technical advance which makes such pictures possible is either hardly noted or ignored completely.

It may be that the technicians of the industry have remained too quietly in the background; or it may be simply that the nature of their service to motion pictures is such that—however vital it may be—it is still one that does not bring automatically to itself popular acclaim and approval in a proportionate degree. At any rate, it is my belief that the moment is at hand when those who are struggling to improve and advance the scientific structure upon which the motion picture rests should insist upon the thoughtful consideration of their activities by the whole industry; not, of course, for any reasons of personal satisfaction alone but because such an attitude will, I believe, hasten the day when still greater technical secrets may be wrested from nature's solitary custody.

The motion picture, in a vastly greater degree than any other art, is dependent for its existence and advancement upon science and invention. The motion picture was born into the world as a scientific invention and not as an art. Only through the blending of the efforts of the imaginative worker and technician has the motion picture become an art and greater heights can only be reached through a happy continuance of this union.

What the motion picture needs in the way of story, story treatment and histrionic development is almost a matter of common knowledge. But equally great is its need for technical advance and of such matters we hear very little.

Laymen like myself are amazed at the thought of the new realms for production conquest that are opened by such a simple development as the process commonly referred to as shooting through glass. This process has, of course, solved countless production problems

* Publisher and Editor, *Exhibitors Herald*.

that seemed insurmountable from both practical and an economic standpoint. When such a development is laid down before the producer in a workable form the progress of the motion picture as an instrument of art and entertainment is appreciably accelerated.

The efforts of the engineers of the motion picture industry have been so constructive and so generally successful that the public has grown accustomed to a rapid rate of progress in all matters affecting the technical aspect of motion pictures. Any lapse in this progress, however, would be immediately detected and a reaction at the theater's box office would be as quickly reflected. Hence, the industry's very status with its public is irrevocably bound up with the fortunes attending the efforts of the members of your Society.

I think it important that we realize that the general public, through the swift-moving stages of technical progress to which it has become accustomed in the production and presentation of motion pictures, has come to regard the camera and the projector as miraculous instruments. This has played no small part in creating the vast appeal of the motion picture. But this condition entails a certain jeopardy and the only escape is a continuance of technical advance in such a way as to cause the public to continue to regard in wonderment the camera and the projector.

However, in the light of what stands in plain view of an observer of what the technicians of the American industry have accomplished there seems to be no grounds whatsoever for apprehension that the years ahead will not bring achievements which will compare favorably with the successes of the past score of years.

I profess no familiarity with the details of the subjects with which your Society is chiefly concerned. But after eleven and one half years of close contact with the motion picture industry in its various branches I do profess a thorough sympathy and concern over all matters affecting the welfare of the motion picture. I, therefore, trust that you will accord kindly consideration to the suggestion to which I now offer:

I suggest to your Society the formation of a central bureau of information and guidance to the industry at large on technical motion picture matters.

Such a bureau would be of invaluable service to the trade press which, in turn, could render a better and more reliable service on these matters to the exhibitors of the country. And with the exhibitors properly informed and advised, accurate information would be relayed to the general public.

In the absence of such a bureau the trade press and the general press frequently are entirely at sea when confronted with the necessity of reporting to their readers correct and exact information concerning technical developments. Doubtlessly, the members of your society can recall many instances in which the press has muddled through with mis-leading and misinformative reports on inventions and discoveries.

Such a bureau as I suggest would be a source to which individuals and concerns could turn for confirmation and guidance. Its operations might include direction and advice to persons who claim that they have improvements to offer. It would be a steadying and constructive force with respect to the technical aspect of the industry. I hope that such a plan may be realized.

DISCUSSION

DR. MEES: The idea that a technical society should form a central bureau of information is one that has recurred and will recur in all technical societies. It has never, as far as I know, been done, and I do not personally see how it can be done in this Society. I favor it, but I think there are various reasons preventing it. In the first place, a society is an assemblage of people. The members are chiefly occupied in selling their services; the members of this Society sell their technical services to various organizations—to companies as consultants, sometimes to the technical press, and in various ways; that is the way they make their living, and it is impossible for them to give those services freely to the world at large. It seems to me that the Society can only give technical advice to bodies such as the United States Government or the Academy of Sciences acting for the government, and to such organizations as the Motion Picture Chamber of Commerce.

MR. QUIGLEY: I hope it will not be necessary for me to disclaim any originality in the suggestion. I did not propose that as new but only as a commonplace need. It seems to me that we are doubtlessly considering this proposition from two different viewpoints. You are considering it from the standpoint of scientists. I proposed it from the standpoint of the editor of a non-technical paper. Your idea of this bureau is far beyond the limitations I should expect to see imposed upon it. If a trade paper in the motion picture industry wants to obtain a simple and rudimentary bit of guidance there is no central source to turn to. The members of your Society doubtlessly have had occasion to resent material published in the newspapers or trade papers relative to some motion picture matter. The reason that such a condition could come about is that while there is no disinclination on the part of an editor to get the facts, there is nowhere to seek them. We might have reported to us next week an alleged perfection of a system for color photography, let us say. It seems to me that it would be desirable to have some central bureau to which editors may turn to ask what is the general nature of this process and its surface characteristics and thereby accumulate enough general knowledge in order to be able to report news intelligently.

Dr. Hickman: I should like to suggest to Mr. Quigley that what is needed is not an information bureau but a library; a place where knowledge could be sought impersonally rather than received from the mouth of an individual. Knowledge, if reliable, is too valuable to give away, and if not reliable would render the Society as its sponsor liable to legal prosecution. Most learned societies have libraries and places where you can get information from current journals and take it at your own risk. Unfortunately our own Society is at present a nomadic body, but a time will come when we shall have our headquarters with a resident secretary. We shall then have a library and much indexed and abstracted literature available to editors and all others seeking photographic information.

Mr. Quigley: With press time two hours away and the reporter not knowing where to turn in a book, the library would not be much help. I think that the type of question to be asked would not be a lengthy one, but one taking only a moment or two to put the questioner on the right track.

Mr. McGuire: I am on the Publicity Committee of this organization and as Mr. Quigley is an editor I have great sympathy with his desire to give the industry more information regarding technical matters. If Mr. Quigley would write or call up the Secretary of this Society he would in most instances be able to secure the desired information.

Mr. Richardson: If such a thing were practical and workable, I should like to see it established. I think sometimes I really know something about motion picture projection after 17 years of study devoted to it, and then somebody asks me something I don't know anything about. A thing of this kind would be well worth while.

AN EXHIBITOR'S PROBLEMS IN 1926

Eric T. Clarke*

A YEAR ago when addressing your body, I confined myself to the problems which were uppermost in my mind, having the idea that, sitting back a year later and taking stock, I should probably find other problems awaiting solution. This year I have only two subjects on my mind. The first is the problem of selecting the feature.

For the three houses which we operate we buy about 200 feature pictures. Add another hundred, which are sent to us to be used if we want them, and you have about six pictures for every one which the Eastman Theater needs. Screening features is lazy work, but an awful lot hangs by it. When I started it, I was advised by an old-time picture man to beware of second thoughts in deciding on pictures. It is the first impression which is important in trying to gauge what the public will like. I have found this very sound advice.

This past year I have become convinced that it is dangerous to be self-reliant in selecting pictures. My personal likes and dislikes, however I may try to sink them, are bound to influence my judgment. With this thought in mind we have in operation a plan by which all members of the Theater Staff who are present at the screening of a feature picture are obliged to submit immediately on the conclusion of the picture their individual opinions concerning it. Screening Room Rules are that those present may laugh and cry as much as they like but that no discussion of the picture will be permitted until all the slips are in. The opinions are later tabulated on the screening report. The final decision must necessarily rest in my hands. To date this plan has worked very well. We played certain pictures which I personally would have turned down. The Volga Boatman, for instance, annoyed me unspeakably; yet it played to a shade better than average business.

We have had much argument as to where to begin in screening pictures, I mentioned last year that we were screening pictures beginning with the fourth reel, but, finding that my associates did not agree with this practice I decided to insist on it only in the case of features exceeding eight reels in length. We are still arguing among ourselves whether we should screen pictures under the best possible

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conditions or under the worst possible conditions. My belief is that we should try to know the worst. Circumstances in the screening room rob us of the atmosphere in the show. We have no music; no audience reaction is obtainable. Consequently I believe we should screen a picture with the eyes of the audience that arrives late, doing this for the same reason that I sit in the worst part of our house in judging a show. If it gets over to me there, I know it will satisfy others.

More recently for our mutual benefit I have been arranging a guessing game with the picture buyer. Each of us makes an estimate at the time the picture is booked. It is a good thing to pin down one's thoughts, and we have already found some valuable results. For example, when considering prospective business on the latest Keaton picture we made an analysis of business done at the Eastman on feature comedies. Setting aside the Harold Lloyd, who is clearly an exception, we find that farce comedies as a whole have not been successful. This is true presumably for the same reason that producers of farce comedies on the legitimate stage prefer small houses. It is hard to play farce successfully if there are many empty seats.

I am still convinced, as I was last year, that most feature pictures running over eighty minutes hurt the chances of success by their length. The past year has seen some improvement in economy of footage, but the relative position of the three major companies remains unchanged. Metro-Goldwyn and Famous Players are still in the lead in this respect, and First National is still far behind, particularly in the product of their own studios. The past year has also seen a reduction in the amount of enforced cutting. The Volga Boatman coming to us 10,600 feet long had of necessity to be shortened unless we were to sacrifice our overture and weekly film news. This I am unwilling to do for any picture. Meantime another problem in this regard has forced itself on us. Several pictures produced in road-show length of two-and-one-half-hour performance have been released for regular motion picture presentations. As the two-hour show is standard with most picture houses, the distributors have issued shorter versions. These come to us already cut, and we get blamed by those of our patrons who have seen or heard of sequences exhibited in a road-show and later eliminated. It is a serious question to which however I can see no answer at the present time.

Ever since the Ten Commandments the use of colored sequences has been the plaything of directors. Outside of The Falcon which did not get a general showing, we have in the past three years, screened but one feature all in color, The Black Pirate. We have had The Wanderer of the Wasteland, which came to us part in color and part tint; also a whole host of features with color sequences. I am not going to get into hot water by talking on color technique. I know little enough about it. For my present purpose, the lack of knowledge is an advantage for I can more easily become the average member of the audience. The number of them interested in color as such is too small to be considered. Personally I do not believe that color helped The Black Pirate. Many of our patrons spoke of recalling only a dark brown taste after having seen it and some even complained of eye-strain. In the case of The Wanderer of the Wasteland, it was interesting to note how the tinted parts seemed to appeal best to the audience. To the exhibitor color at present is no talking point. It does not "get them in." The color sequences in The American Venus, though good, could not save the picture from failure. I believe the fashion show in Irene would have been just as effective in black and white; personally I should have preferred it so. The color sequences in Fig Leaves, as also in Stage Struck, were amusing, but lost their interest after the first two hundred feet or so. To me an ideal use of color is to be found in It Must Be Love where for a brief moment, not over ten feet Colleen Moore sees her father's delicatessen store through the rose tinted glasses of her lover who is buying the place.

In the discussion following my paper last year, I was asked why certain pictures of outstanding importance were not shown at the Eastman. Two pictures were under question—The Last Laugh and The Street of Forgotten Men. I explained that we had not shown either as we thought that only limited audiences would appreciate them. I added that we had shown The Beggar on Horseback, because we felt we owed it to the industry to sponsor such an unusual picture which, as I said, was five years ahead of the public taste. This picture, coming at the height of the season, held the low record for the year. I have changed my mind. I know now that I was wrong in letting the Eastman take sides with Art against the Public. It was not our business to show a picture which the big public did not care to see.

Every theater has its regular patrons. It is the job of every theater to make those patrons want to come every week and to satisfy them once they are in. A theater like the Eastman has an additional job. It should try to lead its audiences to the appreciation of better things. Now this is a matter to be done with the greatest care. Not one of us likes to be preached at, and our resentment can turn to indignation if we think we are being preached at when we have paid our good money to be entertained. In the theater business it is hard to distinguish indignation from lack of interest. True we get oral comments and letters. Letters come almost every week and we get, either direct or through the President of the University, our full share of fan mail and "Nut" letters, but they do not teach anything; they can serve as no guide. No, the trouble is that indignation and lack of interest take the same form;—people stay away.

Now frankly, that is what we cannot stand. If we sold season tickets to the Theater shows, as we do in our concert series, and a fixed number would come anyway, it would be different. We should then, as we do with concert artists, book attractions of high artistic though limited appeal knowing that the audiences would appreciate them once they were in or at least would soon get to appreciate them, but there is no use in talking about educating people by presenting high artistic shows if so many of the people just decide that they won't come. While The Beggar on Horseback was being shown, I was stopped by people I did not know who just "Had to tell me that they thought it was a most awful picture," and I realized then that it had shot right over the heads of such of our patrons as had decided to come and see it.

We, like every other large theater, are organized to please the big public. Compare, if you like, the movie business today with current literature. It is clear that we are in a class with the Saturday Evening Post and not with publications appealing to limited circulation. The Eastman plays to over two million people a year, and our problem is the same as with the Post which sells over two million copies a week. If the showing of an artistic picture means loss of business, its showing at our house cannot be justified. To cater to the tastes of the few while the many stay away is fundamentally wrong. We owe weekly entertainment to our steady movie-going public, and the essential quality of audience appeal must be the foundation of any show we may arrange. To this extent Box Office is King.

Where, then, and how, is our public to be led to appreciate the better things in films? Only by greater subtlety and artistry in the pictures which our public will anyhow want to see. Nobody will deny that this is taking place; that pictures are improving in their quality and art. Many pictures with artistic appeal will today succeed where a few years ago they would have failed. The progress is sure but slow. You cannot suddenly get people to appreciate better art. It has taken four years for our theater to establish any liking for the quiet dignified show which most other houses would class as lacking in punch and box office appeal. But it is no less true that it is by the very pictures of limited appeal that the box office successes become more artistic. The picture made in disregard of the box office may fail, but if it has artistic merit it will leave its mark on the box office of the future. It need not necessarily be a box office failure to be influential. For several days after screening Variety the regular product seemed cheap and commonplace. A friend of mine at the screening said, "I wish that every one of our American directors might be innoculated with Herr Dupont's genius." So far as imitation goes, his wish is coming true in double quick time, and I predict in this season's product many instances of this director's influence. But this is an isolated instance and over against this one there must be a dozen or more artistic pictures with limited appeal. For example, let us take the two pictures we discussed last year, or take Moana, or Grass, or Alaskan Adventures. What about them? Are they not to have a showing? The answer is, "Yes," but it should not be in houses like the Eastman. Nanook of the North comes near to holding the Eastman low record, yet it was a fine picture which gave very great pleasure to those who cared to see it. Still I should be wrong to set in another picture of the kind. The fact is that a picture like The Last Laugh or Moana has proved a real problem to us all along. Certainly there is great credit due to the producers who have made them and the distributors who have put them out, and it is our duty to get an adequate showing for them, even though they are obviously not "Saturday Evening Post" pictures.

My point is that it is up to us exhibitors to organize special houses for showing these pictures of limited appeal. Let us divorce our big appeal business from our limited appeal business. Publishing houses have done this and so must we.

The distributors look to us as their steady customers to absorb these Moanas and Grasses. Most exhibitors, to tell the truth, take them with a wry face because they must, if they want the rest of the product. If they cannot afford to shelve them, they will throw them in during some off week where they figure the loss will be least, consoling themselves with the thought that they are keeping up the tone of their house. How much better it would be to have a special place for showing such pictures to the select audience. Profits would then be possible where now there are losses. A different public would be developed without disturbance to the great public. At present there is not a sufficient number of pictures of this kind to supply a theater all the time in a city the size of Rochester, but it is possible to make a beginning. Once this outlet for pictures of high quality is established suitable product will soon be forthcoming in sufficient quantity.

Fired with enthusiasm for what has been done by Mr. Symon Gould through his Film Arts Guild at the Cameo Theater in New York, I intend to make some experiments this coming year, and am beginning in our 500 seat house, Kilbourn Hall, with Alaskan Adventures a few weeks from now. All I know at this moment is that the showings should be two a day, not continuous, so that pictures like the Last Laugh and Beggar on Horseback will not be hampered by the trouble which people had who came in during the run and stayed for the beginning.

I come now to the other problem that I have been harping on for the last year—that is, building the show. The show that we build around the feature is the chief thing that distinguishes us from the house that merely grinds out film. The presentation is the only way we have of improving on the bare product as it comes to us. Anyone seeing shows at straight film houses will recognize the welcome relief of a few minutes in which to sit back and not look before going on. This is the basis of the deluxe house in its elemental form.

I spoke last year about the wide range of audience taste in that one-eighth cross section of the population of Rochester that must come to us every week if we are to keep alive. The best appeal to this audience is through variety in program numbers. I find this audience appreciative of good contrast and variety but not desirous of the independence and incongruity characteristic of the separate numbers in a vaudeville show. From experience such as that of the last Valentino picture around which we built an Italian bill, I find the public appreciative of occasional bills having a national character, but these should come not more than five or six times a year. In general the past season has proved the advantages of a bill containing around seven items where the feature length will permit. This confirms the opinion of Mr. S. L. Rothapfel, father of deluxe presentations.

In making up the bill, the most important thing is to arrange suitable acts. At present the manager who wants acts and has no facilities for getting them up himself can go only to vaudeville or to the concert stage. I have tried all kinds of talent from these two sources. Neither is suitable to a high class deluxe bill. Vaudevillians have their own particular flavor, and at the Eastman we find that they do not make good ingredient in the bill. The concert platform will yield good talent for movie acts if suitably presented in a theatrical setting. As the Eastman Theater is also used for concerts, we have added reason for distinguishing between the two types of entertainment.

I do not believe in big headline acts which rival the feature in their cost. I do believe in a big orchestra and only when that orchestra is away on vacation will I set in big acts. Then I reverse the policy of the house. During the regular season my aim is to build everything up towards the feature—not to overshadow it.

It is impossible at this time to describe the character of the acts which the deluxe presentation needs. In each show that we are arranging we try to get further experience in this direction, and maybe after another year I shall be able to make some more positive generalizations. At the present moment I am using as my guide an aphorism of a modern French writer who says, "The public always wants to understand first and feel afterwards." There is a big home truth in this, and my instructions to those preparing our acts at the Eastman are, "Have in the act a clear reason for its being there, then you may commit the grossest forms of highbrowism." The acts which we want must explain themselves without need for program notes. It is only too true that the tired business man watching a ballet will say to himself, when he sees the apparently aimless prancings, "I don't know what it is all about, but I suppose it must be good, because her name is Pavlowa."

At the present time, no act of ours is permitted to run longer than ten minutes; we find it entirely too easy for our cast to outstay its welcome. Economy of time consequently becomes an all important factor. And to me it is interesting to see how slow by comparison a vaudeville show now seems.

I am further convinced in my objections to prologues. It is true as I said last year that, "An atmospheric prologue can sometimes be arranged successfully where the aim is to get the audience into the right frame of mind for viewing a feature picture, but there is little sense in presenting an act based on a picture which the audience has not seen." I am almost sure that a contrasting number is in its way as effective as an atmospheric prologue. In arranging the presentation of Variety, we built contrast to the sordid and heavy feature by presenting a ten minute excerpt from The Pink Lady.

Around the acts, of course, it is necessary to have film; the deluxe show is not a vaudeville show, and the acts should be spaced apart. In looking for this film, the first job has necessarily been to drop comedies. I am sorry for this, but it is unavoidable. If after setting in the overture, weekly film news and comedy, I have twenty minutes, I would rather not give it all to one comedy, but say, to an act of five minutes, to a scenic, cartoon or novelty of eight minutes and to another act of seven minutes. Hence we are faced with the need for one-reel comedies. Unfortunately there is a distinct shortage of them, presumably on account of the extra price which the distributor usually gets for a two-reel subject. So, in the absence of one reelers, the comedy has had to go out of the bill.

Roughly we can divide comedies into two groups—story comedies and nonsense comedies. I noted last year a healthy tendency toward story comedies. Unfortunately such comedies made in two reels cannot readily be cut. Universal Pictures has a plan this season for selling two-reel comedies and delivering them to deluxe houses already cut to 900 feet, but unfortunately the type of comedy which lends itself to such drastic cutting is not often suitable for our needs.

Having few if any comedies to draw upon, our need is for short novelty films. Among these we have found scenics acceptable if we present them with a special musical accompaniment, so that the audience has something to hear as well as to look at. Without such aid a scenic will not get over. We have found the series of Fox Varieties very good. They are convincingly proving that intelligent cutting and continuity work will bring success in a line which many others have tried and failed. We find our audiences get tired quickly of any one brand of cartoons, so we have to space them several weeks apart. Conditions like these leave us continually in need of one-reel and half-reel subjects. In the Eastman I have had no particular success by including as individual items such composite reels as Pathé Review, Searchlight and Reelview. We find them attractive to our audiences if we take out the best shot and include it in the weekly film news.

The weekly film news, as I said last year, is in importance second only to the feature. At the Eastman we have found it best to make it the first film shown on the bill. During the past year we have developed our news in every way possible. Besides taking all four services we have added local news to our weekly. This is a particularly useful addition and can be strongly recommended to other cities. By tying up with the local daily papers we are able to secure the selection of several subjects at the bare cost of the film and the titling.

We do not at the Eastman show the standard jokes issued weekly under the name "Topics of the Day," because we do not consider such issues as really suitable to motion pictures. Many people hold it to be an invasion of a field better covered by periodicals. In our other houses we have found the regular presentations of these Topics to be most successful if they are introduced into the weekly film news, and I am indebted to Mr. Robert C. Bruce for the suggestion that they should be presented without any musical accompaniment. We find that the jokes get over better; not so much from their humor but because there are always people in the audience who read quickly and laugh early or late, also whose laughter is contagious. Music in its capacity as a soothing influence seems to hinder the laughs.

I must close my paper as I did last year with the depressing fact that speeds in weekly film news are as bad as ever. I wish it were possible for the Society of Motion Picture Engineers to conduct an inquiry among camera men as to their manner of cranking. Recently Mr. D. W. Griffith told me that his men were photographing with the idea that the pictures would be exhibited at 90 feet per minute. Among ourselves we believe his productions go best when run nearer 100 feet a minute; but, if only the news reel camera men had in mind an ultimate projection speed of 90 feet per minute we should see a vast improvement.

DISCUSSION

MR. RICHARDSON: I believe that the particular type of paper presented in Mr. Clarke's inimitable and very excellent way is perhaps of greater practical value to the industry than any of the very excellent papers we have. I only wish every exhibitor in the United States and Canada might have listened to what Mr. Clarke has said. I do hope Mr. Clarke will be induced to present papers at future meetings of the Society. I would suggest one on projection and its possibilities. This week I was called in by the United Artists, which organization has been having trouble with projectionists who do not want to run the "Black Pirate," a production in Technicolor, at the speed recommended. I have had certain scenes screened at different speeds, and I ran into something I am unable to understand, although I think I may have found an answer to it. I found that 80 was about the best speed for the action—probably better than a higher speed, but the speed which the United Artists have recommended does not set up any serious injury to the action. It, however, seemed to be true that the minute the speed is reduced below 85 the colors are not so bright and sharp. I want to ask you if you have noticed any effect of this kind in the projection of color pictures and if so what you idea of the reason is.

Mr. Clarke: You are asking me a question beyond my knowledge personally. The all-color features we have so far shown, also the color in black and white features have been run at twelve minutes per thousand or at a speed of 83 or 85 at the most. We slow down for our color pictures purposely.

Mr. Palmer: What is it that determines the size of the audience? Do people go because of the name of the picture? Was it because the audience on Monday told their friends they did not like the picture that the friends did not come on Tuesday? Was it what they read in the newspapers or what is it that makes people dislike one picture and like another?

Mr. Clarke: When I came to Rochester the stage manager of our theater said to me, "I like Rochester, its size is still such that the majority of shows are made or broken over the washline Mondays." We cannot definitely pin down the thing that induces people to come. I know from personal experience that when the house opens on Sunday the audience somehow knows whether or not it is going to enjoy the picture. Most of the people come from advance information or the attractive sound of the title. The title means a great deal. With "Nanook" the business opened poor and remained so. With "Variety" the business started average and increased steadily during the week. But there are only about five weeks in the year, I should say, when that happens. As a rule, the business for the week is divided up over the various days on a fairly constant series of percentages. We have at times tried special advertising campaigns on certain pictures. I don't like doing this at the Eastman because we are playing to the same audience week after week, and I try to keep the advertising on an even keel; it is anyhow hard to prove that special advertising has any real effect. Somehow—the boys at the theater say—the audience smells them out beforehand.

Mr. Peck: What is your opinion on the future of the straight scenic picture and the approximate length most suitable for your theater and perhaps for other theaters and exhibitors?

Mr. Clarke: Do you refer to a scenic picture of feature length?

Mr. Peck: No. The short one-reel subjects.

Mr. Clarke: The straight scenic presenting nothing but outdoor shots is good probably for not over 400 feet. With good continuity and interesting subtitles I should say that the time could run up to 800 feet. The Fox varieties—and they have had greater experience in this—average 750. The pure scenic is of value to us only as the basis for an act presentation. Pictures of water falls projected on the curtain, not on the screen, fading into an act with appropriate music can be used, but there the average film will not run over 200 feet.

Dr. Hickman: I think that one of the main points of Mr. Clarke's paper is that for all time the director's chief problem is the selection of feature plays which will fill his theater. Mr. Clarke occupies an authoritative position in one of the biggest theaters and this fact separates him from his patrons. The films he likes they will not necessarily appreciate. After screening a feature he has to determine whether or not he likes it, and then modify his opinion to suit an audience. He must form an opinion and then make a sort of arithmetical addition or subtraction and announce the result as his patrons' taste. I suggest that there will be a tendency for the breach to widen in Mr. Clarke's mind and cause him to modify his opinion more than is actually warranted. Would it not be possible to admit a quite uninitiated audience to the screening room and note their preferences? Their opinions might be asked of two test films, for instance, "Stella Dallas" and "Variety," and the audience finally compounded of ten who liked the former and two the latter. That would enable public taste to be found first hand at a sufficiently depressed level.

My second point follows from a remark by Mr. Palmer. There is no doubt that many a highbrow picture comes to the public distilling a subtle aroma of failure which dooms it before exhibition. One can almost hear the box office saying, "Exquisite, but too refined for the public nose." I suggest to Mr. Clarke that the higher class pictures never receive the heralding and pre-announcement accorded the lighter and at present more popular material.

Mr. Clarke: The fear that we might, in selecting for our public, play down to a point below what they would accept is a legitimate fear until one realizes that if you do so, you will get left almost immediately. Pictures made with an obvious effort at placating the box office come to us all the time and more often are hopeless failures. Very few pictures that are designed to be box office pictures succeed as such. I am not afraid of any tendency on our part to lose touch with the best side of our audience. Coming to the question of a representative group to screen: It is one of the peculiarities of the business that one gets no average reaction. I spoke in the paper of fan letters and "nut" mail. Exactly what the reaction of the audience is, it is impossible for us to judge. I have tried at various times selecting people to attend screenings, but no matter how large a number I might select, I have concluded that I cannot make it representative. If it were as simple a matter as saying, "Did you like Variety better than Stella Dallas?" it would be simple, but few people know their own minds when you ask them such a question. In the second place, the judgment that we would get from the committees would probably lead us wrong as often as it led us right. Perhaps in this paper I have not sufficiently emphasized the problem we are faced with in making these decisions. All I know is that there is a very wide range of personal attitude, and I have found success in consulting the various people connected with us, but have found no success in following the opinions of those who are not living with it. It is a difficult question.

Mr. Peck: What has been your experience on industrial films of one reel length?

Mr. Clarke: I can classify industrial films with scenics. If the subject is one of general interest, I have no hesitation in showing it. I call to mind many varying shades of so-called industrial pictures, running all the way from basic industries down to almost bare-faced advertising of specialties. We had some of the Fox varieties dealing with basic industries—pictures having to do with logging, with gold mining, pictures taken in salt mines in western New York. These are very interesting. The pictures in the more special lines of manufacture are not sufficiently interesting to justify inclusion as a separate item. Pathé Review will have often an industrial subject, and about 150 feet will be as much as we can use at one time.

THE LITTLE THEATER MOVEMENT IN THE CINEMA

Symon Gould*

ALL art movements have their inception in minorities. In the beginning, their purposes are regarded with indifference, often with suspicion. But if their aims are sound, they slowly pass through various progressive stages of transition which ultimately evolve into the practical. Certain art movements, of course, are exceptions to this process, but these exceptions are so individualized and ego-motivated as to be of little use to civilization excepting as passing phenomena of the life-spectacle.

The film-art movement, however, is, I believe, destined to a wide acceptance because it can draw its first energies from the tremendous reservoir of present-day motion picture production and for the reason that its propelling principles are not revolutionary, but evolutionary.

The question has often been asked of me, "Is there a necessity for such a movement? Are not the producers themselves concerned with injecting elements of sincere artistry in their production?" It cannot be gainsaid that important strides have been made by producers in creating films which make every effort to be finely done, and in many instances their attempts have been crowned with success, but it must be conceded that the very nature of motion picture production as it is constituted to-day with its intense commercialized conditions, increasing in magnitude daily, cannot make for a healthy atmosphere in which the artistic cinema can thrive, excepting in isolated examples.

Then, perhaps, that changing chimera, the Public, is not ready for the better and best motion pictures. Many arguments, reinforced by irrefutable box-office data, can be summoned to support this contention. History proves, however, that the public was rarely, if ever, ready to accept any change and that means were always necessary to convince it.

This is the function which the Film Arts Guild and other groups throughout the country have assumed, feeling, as they do, that the cinema has an art-destiny of its own, unrelated to any other existing

*Director, Film Arts Guild.

art, and that a little theater movement of the cinema is essential at this time to keep the flame of its artistic ambitions burning brightly and shielded from the miasmatic vapors of the commercial animosities of production forces.

The film-art movement, in brief, has dedicated itself to the task of reviving and keeping alive the classics of the cinema, as well as those films which may be noteworthy for the best elements which contribute towards the greatness of a motion picture, such as theme, characterization, composition or cameracraft. Literature, music and the other arts have their classics and there is no reason why the great achievements of the screen should not be preserved and handed down through the generations.

The *modus operandi* of this idea is international in scope as its aim is to establish repertory cinema-theaters in communities throughout the world where the films worth commemorating and preserving to be presented. This form of repertoire is naturally not to be confined to American films, but there is to be an interchange of films representative of the best of each country. Art has no frontiers and recent experiences with films here indicate that Europe and perhaps other continents can contribute motion pictures which attest to the highest qualities of cinema values.

With this plan in mind and in order to give the movement a true impetus, the Film Arts Guild has engaged the Cameo Theater, situated on Forty-Second Street near Broadway. This is a small house seating 540 people. During an elapsed period of the last seven months, three of which included an abnormally hot summer (and the Cameo has no cooling plant), it has demonstrated the complete success of the screen-repertoire idea. It has played many box-office failures during this time and has in nearly all cases won for them belated recognition and a new public, the latter in many cases consisting of screen-skeptics, people who rarely attend motion pictures or who have a low opinion of them gained by a few sad experiences with stereotyped films of the usual order.

On several occasions, the Film Arts Guild has presented European films, which had fought unsuccessfully for recognition through the regular distribution channels, and these were invariably acclaimed by the press and later, by audiences at the Cameo when presented in our regular repertoire.

On the basis of our regular experience with this theater, I see no reason why, backed by an organized effort on the part of the industry, similar repertoire programs cannot be introduced in communities throughout the country. Of course, it is too optimistic at this stage to expect the old-line exhibitor to support this idea in his presentations. His reluctance, however, is natural and springs from the commercial wariness with which he must watch his competitor's moves and movies.

For that reason, the only present hope, as I can see it, for a widespread establishment of the film-art movement is in co-operation with the little theater movement of the drama. There exists to-day a thousand individual producing groups, ranging from amateur clubs to the true type of institutional playhouse. Many of these groups, dedicated to the better aspects of the drama, and wielding an important cultural influence in their communities, could be interested in presenting, at least, once a month, special programs of films, consisting of outstanding motion pictures, many of which might have met with undeserved failure or little success when first shown in those same communities.

As a matter of fact, just now there is a movement on foot to weld the interests of these thousand dramatic units into a huge communal group and administer their financial and dramatic needs through a clearing house. If that condition is consummated, it will be relatively easier for a film-art movement to offer its plan for embodying a cinema auxiliary in the programs of these various dramatic units.

The local exhibitor would not suffer from such presentations. In fact, it would benefit him. First, it would focus more attention on motion pictures in his locale among those persons who have hitherto had small interest in them. Second, it would enable him to enlist the attention of such groups in his community when he presents a film of artistic merit of current release. Third, he would always be at liberty to present repertoire programs of his own arrangement modeled along film-art lines and he would be certain of support for such showings on the part of this new-found public and the press, as well.

The producer would benefit as follows: First, it would place a new value upon many of his films which now enjoy a limited circulation and in many instances are deadwood, or rather, dead celluloid. Second, it would give a definite impulse, which can be regulated on a schedule, for revivals and re-issues and exhibitors would gradually become educated to the advantages of playing a good old film rather than a bad new one. Third, it would enable him to ease up on his rush-order, multi-film policy of production and permit him to spend more time on the making of pictures with the result that better films would probably become the rule rather than the exception. Fourth, by emphasizing and achieving these points in his general organization of producing and distributing, it would enable him to build up a list of films which would have a big re-sale value over a greater number of years, similar to a publisher's list of books, which include Shakespeare, Stevenson, Ibsen, Shaw, Mark Twain, Dickens and others.

I feel that every producer should appoint a special individual in his organization to give his concentrated time and attention to this aspect of the film industry and its possibilities. And, to go further, I suggest that a special bureau be created in the Hays office to co-relate all these activities and bring them to an effective focus so that all producers may benefit by the mutual interchange of ideas and experiences along these lines. I feel that this suggestion should be given most serious consideration as I believe that ultimately the public, producers and exhibitor can profit through its correct application.

My basic contention is that the motion picture industry suffers from overproduction. It is its weak spot and is proving destructive to its best interests. Eight hundred films it is said, are scheduled to be produced during the next twelve months. Each represents financial hopes. All are primarily aimed at the box office. Stereotyped plots and weak characterizations will predominate. True imagination and real intelligence will be lacking in most of them. How many will survive six months . . . . how many a year? Can you for a moment visualize the great effort which will be necessary in their making? Most of these films will resemble their predecessors quite suspiciously. The same type of players will be featured in the same type of roles regardless of their particular suitability for the parts. In many instances, the plays will be made to fit their personalities . . . . manufactured personalities in certain cases. And all this for whom? For a public which has been stupefied into accepting them through extensive and expensive publicity campaigns. And, in some cases, there will be a sugar-coating supplied with tabloid vaudeville featuring second and third-rate artists.

No one can deny that this condition exists. But one must also admit that some producers are beginning to sense a movement on the part of that slowly-turning worm, the movie-audience. The remedy, as I see it, lies in a more deliberate and intelligent form of film-production, relieved and heightened by regular revivals and re-issues of old films of merit and leavening the whole with imported motion pictures of special merit. This may relax the tension and errors of overproduction and lay the foundation for methods and policies which may be more conducive to the creation of films which will have longer runs and longer lives and be carried on for presentations through generations.

Under such auspices, the conditions also become more propitious for the birth of the truly great cine-masterpiece which will be able to vie with the great creations of the other arts and prove to the world that the silver screen can body forth an art as appealing as the others in its universal note of feeling and expression.

There are two other suggestions which I am taking the liberty to make in connection with the film-art movement. Every similar movement in an art field has its journal of expression. At present, in the welter of motion picture magazines and trade journals one rarely finds a note of true vision of real interpretation. I feel that the industry should subsidize a periodical which might be called, the Film Arts Monthly. It need not be highbrow, but each month it can proclaim the major achievements of the screen. It might help to develop a new school of critics and criticism, some of whom are already beginning to sprout in our daily press. It can concretely emphasize the gradual development of the film into a dynamic art form. It need not serve as an album for the delightful photographs of stars, except as their faces lend themselves to unique or vital character studies. It would also print illustrations of or originality in designed settings. It would devote pages to the best examples of camera craft, the aesthetics of the films, its musical aspects and other views could be presented by selected commentators. It would report unbiassedly the activities of the studios of the world.

The other suggestion I have has to do with the establishment of a class or school which would develop what I am pleased to term, screenwrights . . . . those whose talents would be trained to write directly for the screen. Such a class can be constructed along the lines of Professor George Baker's famous 47 Workshop, of Yale, which is dedicated to the technique of the drama. I believe that such a class, located in Hollywood for practical purposes, but removed in a certain degree from its mental influence, at least, in the beginning, would prove of great help in supplying a new force for the betterment of the cinema. The initial task of organizing and directing such a class could be undertaken by some single individual who has shown himself to be of outstanding merit in his work for the screen. He could gather about him other screenwrights who through lectures and by practical demonstrations develop a curriculum through which could be conveyed the essence and viewpoint of screenwrighting.

There is no doubt that this is the age of celluloid. We are only standing on the threshhold of unforeseen developments in this momentous field. It remains for those far-seeing executives at the helm of the industry to give a few of their subordinates sufficient rein to strike out in new directions. Many of them are irked with the methods in vogue. Ideas of transcendent value to films are pent up waiting for release. Believing this to be true, I offer the film-art movement as an instrument to achieve a modicum of this progress. I feel with the industry behind it, it can accomplish much of artistic and practical worth.

The Manie Color Film—"Der Filmpost", the recently founded organ of the Union of South German M. P. Theaters, announced in its first issue that an exhibition was recently given of this new process, that is based on the "already proved" patents of Möbius, Lasogga & Noack, of Königsberg. It is stated that: "all colors, even crimson and violet, which have hitherto been the most difficult, are rendered in the pictures in their natural gradations. Even metallic, golden letters etc., appear with their characteristic sheen on the screen. The pictures were taken and shown at a speed of fifteen per second. The important points of the new process are stated to be that there are no difficulties and that thus the pictures are no dearer than ordinary black and white films. Two processes may be used. In the one the different color images are taken successively. In the second method but one lens is used without any stereoscopic effect. The results are the same by both methods—a flickerless, true-to-nature picture. The second method has the advantage over the first that there is no color parallax. It is a suitable, therefore, for any taking speed and trick work. Neither the negative nor positive require any special chemical treatment. The printing process is as usual. The customary camera and projector can be used without any alteration—except placing a special arrangement, on the lines of known filters, in front of the lens. (Filmtechnik, 1926, 2, 446).

RECENT DEVELOPMENTS IN "THE PHONOFILM"

Lee de Forest

ALTHOUGH as far back as 1900 I first dreamed of some day building a new phonograph in which the photographic emulsion should replace wax, and a ray of light the steel or sapphire needle, yet it was not until 1918 that my attention was really focused on the field of talking pictures, or more broadly of recording sound by photographic means.

Perhaps I can best bring my readers to a concise idea of the problem as it then presented itself to me by a brief résumé of a former paper presented on this subject.

At the beginning of my work I laid down several principles, based wholly on commercial considerations, limitations which I considered the talking motion picture must, in order to be commercially successful, fall within. These considerations were—

First—nothing but a single standard cinematograph film should be employed;

Second—the speed must be that of the standard motion picture film;

Third—the recording and reproducing devices must be absolutely inertialess, excepting possibly the diaphragm for receiving and the diaphragm for reproducing the sound;

Fourth—the microphone device must be sufficiently sensitive to permit its being successfully concealed at a reasonable distance from the speaker or source of music to be photographed.

Fifth—the reproduction must be as good, or better, than the existing phonograph, and loud enough to fill any theater where the talking pictures should be exhibited;

Sixth—the photographic sound record must be so narrow as not to materially cut down the size of the normal picture projected on the screen;

Seventh—the photographic record, therefore, must be one in which the *width* or *amplitude* on the film was constant throughout, and the sound variations must therefore be photographed as variations in density in the photographic image. In other words, the light record should be in the form of exceedingly fine lines or parallel bands of varying densities all of the same length, and lying always transverse to the direction of the motion of the film.

(Of these seven requirements the simultaneous development of the Radio Art and the Public Address System has furnished for us ready-made two essentials—a satisfactory "pick-up" microphone, and an adequate loud-speaker reproducing unit).

To photograph the highest harmonics of any music which it might be desired to record upon a film traveling at normal speed, i. e. 12 to 16 inches per second, necessitated a slit not more than one-thousandth of an inch in width. And in order not to appreciably cut into the size of the picture on the film the length of this slit must not exceed at most three thirty-seconds of an inch. This in turn necessitated the employment of an intense light source small enough to go into the moving picture camera, and yet one whose intensity could instantly and proportionately be varied by the slightest and fastest sound vibrations which it might be desired to record. Some of the above conditions were by no means easy of realization.

At the start I undertook to photograph the light fluctuations from three different sources: that of the speaking flame; that from a tiny incandescent lamp filament. The other of the three methods which I originally and simultaneously set out to develop proved in the end the simplest and most practical method for producing by electrical means light fluctuations of sufficient amplitude to be photographed in every necessary degree of intensity.

The light that I employed for this purpose was that of a gas-filled tube which is called the "photion".

Briefly the process of recording speech as as follows—referring to Figure I—

The microphone pick-up translates the sound vibrations into electric currents. These are amplified several hundred thousand or million times and these amplified telephonic voltages applied across the terminal of the photion gas-filled light in which a normal luminosity is constantly maintained by means of a few hundred volts of direct current. The photion tube emits a violet light which is highly actinic in quality. The intensity of this light increases and decreases around its normal brilliance in exact correspondence with the modulated audio frequency energy from the amplifier. The light from the end of this tube is focused by means of a lens upon the very fine slit directly upon the film. This photion lamp is placed inside the moving picture camera at a point where the film is moving continuously some ten inches away from the window of the camera, at which point the motion of the film is intermittent. The combined picture and sound record thus made are obviously in absolutely fixed relation to each other, and there is consequently no problem of synchronization to be solved. It is only necessary that in the projecting apparatus the sound reproducing device shall be the same distance from the picture aperture, measured along the film, as was the case in the moving picture camera where the voice and the picture were originally photographed.

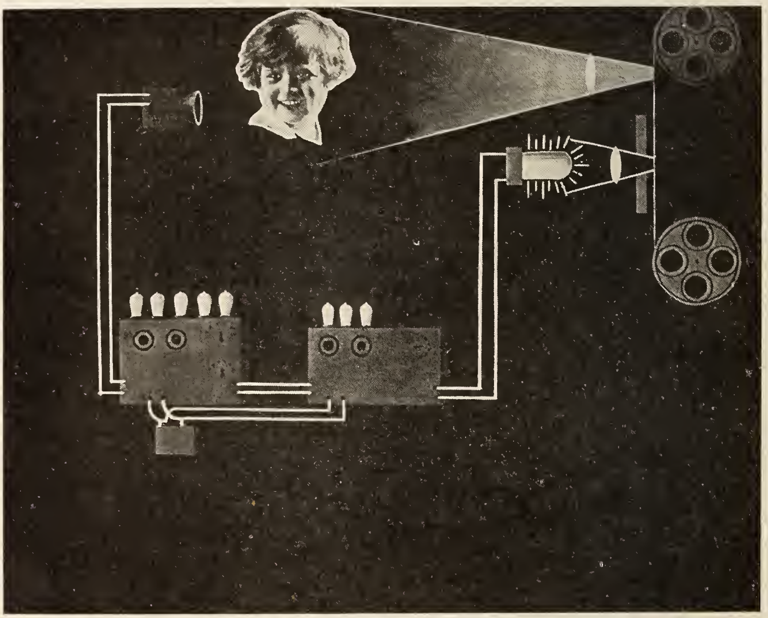


Fig. 1.

This sound record is photographed upon the narrow margin of cine film reserved for this purpose, which is masked from the picture aperture. The negative is then developed by a special bath which has been worked out as a result of long experimentation and study—one especially adapted to accentuate the contrast exposures in the sound record and at the same time to bring out the desired photographic qualities of the picture. In printing, the negative and positive films are run through the printing machine twice, once for the sound record at which time the picture is not exposed, and again for the picture, the sound record being then unexposed. This double printing is desirable or necessary because ordinarily in the camera the distance between the sound recording slit and the picture aperture measured along the film is not at all the same as that between the slit and the picture aperture in the projection machine. Therefore, to accomplish perfect synchronization, the distance between the sound record and corresponding picture must be made that which the mechanical arrangement in the projector itself demands. Moreover an entirely different printing light value is ordinarily required for the sound from that required for the picture.

The next chart—Fig. 2, shows in the same manner the arrangement used in the projector. Between the upper film magazine and the

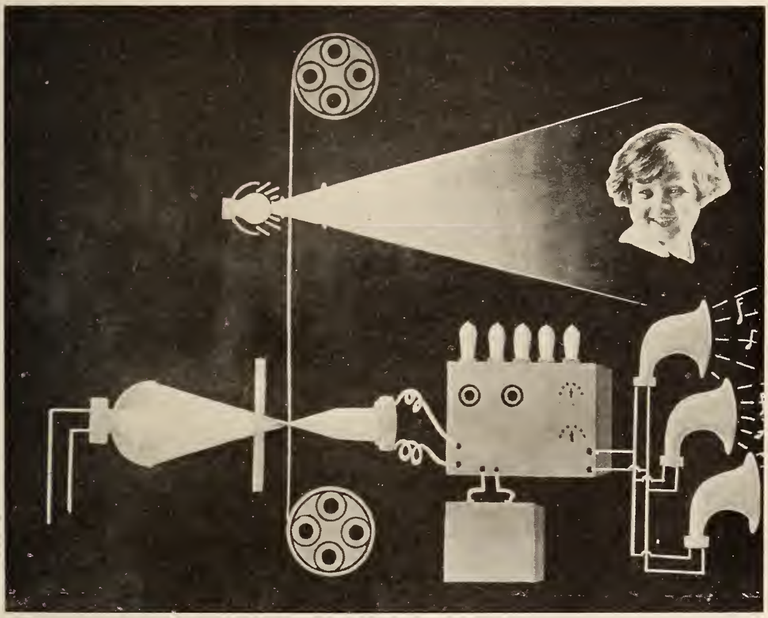


Fig. 2.

intermittent, step-by-step, mechanism of the standard moving picture projector machine are located in two small co-axial metal tubes, the sound projector lamp and the photo-electric cell. The light from this small lamp is focused upon a fine slit having the same dimensions as that in the camera, passing thence into the photo-electric cell, which is a few inches in front of the slit. Across the slit and in close contact therewith passes the film on which the original photographic image of the sound has been photographed and printed. The fine lines of light and dark, which represent the sound record, passing across this tiny slit produce corresponding variations in the light beam which transverses the slit and falls upon the photo-electric cell. Now in series with this photo-electric cell are connected a dry battery and the grid and filament of the first tube of a specially designed four-step, audio-frequency amplifier. This amplifier, which has been designed with great care to avoid, or correct, any form of distortion, greatly magnifies the minute telephonic currents thus generated in the photo-electric cell. The output circuit of this amplifier is then connected by means of a two conductor cable to the loud speakers which are concealed above or on each side of the screen, on which at the same time the corresponding motion picture is being projected.

At one time I employed the thalofide cell of T. W. Case as being particularly sensitive. It having been proven, however, that the thalofide cell evidences a very decided lag to high frequency light changes, this cell has been discarded in favor of a type of potassium mirror photo-electric cell of the type originally developed in this country by Dr. Kunz of the University of Illinois.

For sometime I have been fairly familiar with the methods used in recording and reproducing the phonograph records used with the Vitaphone and in the methods there employed of synchronizing both to the camera and projection machine in the theater. I can say without hesitancy that they represent the nearest approach to perfection of recording and reproducing voice and music which has ever been reached in the phonograph art. The effects which have been obtained in recording a large orchestra are truly magnificient. The Vitaphone is truly the *Apotheosis of the Phonograph.* It represents the culmination of a long series of endeavors on the part of many to synchronize the phonograph with the motion picture machine, dating back as far as the earliest work of Edison in this direction. Every step of the process has been engineered by the Western Electric Company's experts in a masterly manner.

To say that the audiences who attend Vitaphone performances at the Warner Theater are thrilled and electrified would be but trite reiteration.

In solving the Phonofilm problem however we did not have the background of intensive development of the phonograph art to aid us. The difficulties encountered have been largely of a different and novel nature. We have nevertheless already gone far enough to prove that the Phonofilm method is capable of every perfection which has been achieved in the latest development of the phonograph art. I do not think this statement should cause surprise among scientists who have given the matter of the principles involved in these two methods—phonograph and phonofilm—careful consideration. For as distinguished from the phonograph art, the phonofilm method operates almost entirely through inertialess matter. The mechanical motion involved in recording and reproducing are limited to the diaphragm of the recording microphone, and to the mechanism of the loud-speaker reproducers. The rest of the process is electrical, electronic, light, or chemical. It seems reasonable therefore to expect that a nearer approach to absolute perfection will ultimately be obtained along these lines than when working with mechanical devices for wax cutting, shellac stamping, and needle tracking. And I believe that the best results Phonofilm have thus far revealed demonstrate that the above conclusion is soundly based on facts.

From a practical manipulative standpoint there can be little question that the Phonofilm method lends itself much more easily to the requirements of the motion picture art than does the phonograph. In the first place synchronization is invariable and absolute. The apparatus both for recording and for projecting is therefore inherently more simple. The motion picture limitations of Phonofilm are but little greater than for the silent picture. With Phonofilm we can cut in and out from long-shots to close-ups, eliminate undesirable portions of a picture or insert others, titles, extraneous matter which may be later desired, etc. etc., with almost as much freedom as when the voice itself is not photographed upon the film. Then of course it is obvious that if the film breaks the torn portion can be cut out without in any way affecting synchronism thereafter.

The operator has only one medium to think about—a single standard celluloid film. And I believe also that the apparatus which the operator must manipulate and care for is necessarily simpler with Phonofilm. It is undeniably very much cheaper to build and install.

From strictly commercial considerations therefore, having in mind the practical and money-making side of the business, I find myself—even after the magnificent performances of Vitaphone—more than ever firmly convinced that the right way to solve the problem of the talking motion picture, and the musically accompanied feature picture, is that of photographing the sound waves on the film rather than by means of the synchronized phonograph.

In any event I am glad to note that the film industry, for the first time since the inception of the art, is ready to welcome the so-called "talking-pictures", and am convinced that in a very short time they will prove a most important part of every program. Warner Brothers deserve great credit for having shown the necessary imagination and courage to awaken the Industry to these possibilities.

The question is often asked "What happens when the film becomes torn? Is not synchronism lost in a film that has been patched together?". Where pictures are taken, as here, at the rate of 20 to 22 per second, one or even two "frames" may be cut out of both voice and picture records without the flaw in exact synchronism being ob-

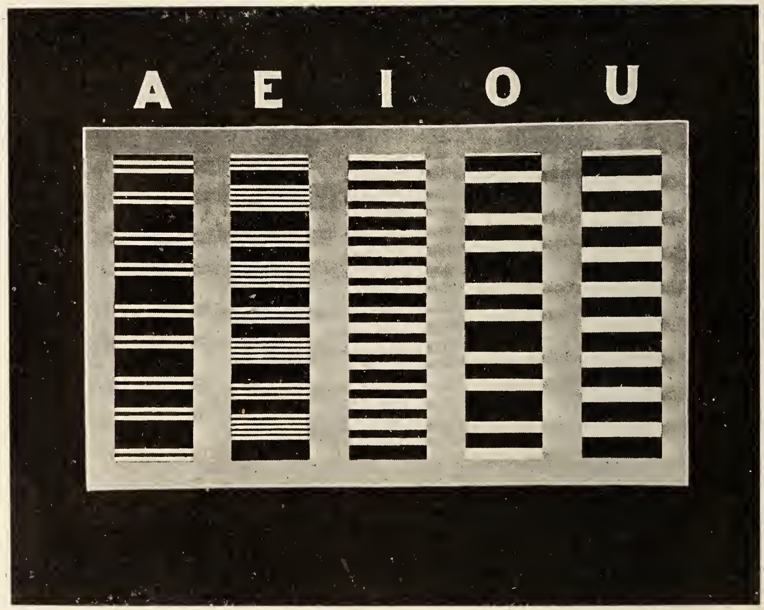


FIG. 3.

servable. This holds true even though the picture is some ten inches ahead of the corresponding voice record. However the sharpest ear will not notice the omission from a voice or music record of a portion occupying not more than one twentieth part of a second.

Of course should a film become badly torn, or worn out, it must be replaced by a fresh print, as in any motion picture film.

A comparison of the photographic records of various sounds, as of the five vowels, is interesting. Some of the patterns here are very pretty and symmetrical—that of the letter E particularly. See Fig. 3.

In studio practice with sound recording, new methods must be introduced in contrast to those heretofore employed in the ordinary motion picture. For example, everyone must work in absolute silence except the actors or musicians who are being actually recorded. This involves, of course, studios particularly designed for this work, with every precaution taken against extraneous noises and interior echoes. The usual hammering, pounding, and general bedlam which has heretofore distinguished the moving picture studio must be completely eliminated while recording.

A new type of moving picture director has been evolved, who directs by signal and gesture only. Special means must be taken to shield the highly sensitive transmitters and amplifiers from electric induction from the various types of lamps which must be employed and the cables leading thereto. The noise of the camera must be completely suppressed, or kept from the microphones. However these difficulties are not serious. We have made great progress along this line, and our productions are each week coming nearer to the ideals towards which we have set ourselves to work.

Already we have combined the Phonofilm with color, and we expect to be able to release films combining this doubly charming novelty within a few months—the picture in color, the sound record in black and white. We believe this will indeed mark a great advance towards that perfect realism on the silver screen of which we have all dreamed, but which in its perfection can never be attained.

We have Bell-Howell cameras with the photion attachment which, combined with a portable transmitter and amplifier unit, permit readily of the Phonofilming of outdoor subjects; for example open air band concerts, pictures of waterfalls, ocean surfs, singing birds, farm scenes, and similar subjects where nature has combined the beauties of sound and form.

The Phonofilm has already been sufficiently tried out in a large number of theaters (over 50 now) under actual cooperating conditions to demonstrate its commercial practicability. A large number of subjects—musical, vaudeville numbers, lectures, operatic, comedy and drama, have been recorded and tried out on various types of audiences. A vast amount of useful data, mechanical and psychological, has thus been amassed—as a result of which we are formulating our policies in development of this form of entertainment. Surely the astonishing success of the Vitaphone on Broadway has already demonstrated beyond cavil that the public like this type of entertainment immensely.

In the Phonofilm type of presentation many unusual or unexpected requirements had to be met: for example, the conditions for linking the sound reproduction with the picture upon the screen in such a manner as to produce a maximum degree of illusion that the spoken words are actually coming from the lips of the speaker on the screen. It is obvious that some correspondence in magnitude must obtain between the size of the picture and the bigness of the voice in order to sustain the illusion. A giant face must not speak with an ordinary human voice; nor must a long-shot representing a man of only normal size speak with the stentorian tones of a giant. Yet faithful reproduction must be had loud enough for all the audience to hear it comfortably. The mixture of acoustics with applied psychology is here very interesting. One of the great advantages of Phonofilm is that, in common with the "Public Address" system, the voice of the screen image is far more distinct and clear in the far reaches of the house and gallery than would be the normal human voice of a speaker on the stage.

But in this connection there may be an apparent distortion of the voice when its intensity in the ears of the listeners is too great or insufficient. When a speaker uses a normal tone his voice contains a larger percentage of the lower frequencies than is the case when he raises his voice to fill a large auditorium. But if the loud speaker amplifies this voice so that it reaches most of the audience with such volume that they instinctively know that the speaker should be shouting, then in reproduction his voice sounds heavy and unnatural. It is desirable therefore to so regulate the degree of amplification that the audience in the furthest rows of the balcony may hear comfortably. The sound volume should not be made any louder than necessary to meet this requirement. Conversely, if the sound volume is insufficient certain of the weaker speech characteristics are entirely lost and it becomes difficult to understand.

In seeking to meet these requirements we have developed a special type of loud speaker horn whose increase of area from the small apex to the aperture follows the logarithmic law. A horn of this improved design energized through one of the new type of loud speaker units driven from a 20 or 50 watt amplifier, is capable of filling the very largest theater with convincing volume. Two such horns placed in the orchestra pit, for better sound distribution, can reproduce the incidental music which has been phonofilmed on the margin of a feature picture with sufficient energy to simulate a fifty-piece orchestra; this without distortion or blasting, but with all the richness of the bass instruments and the trumpets, at the same time observing with fine distinction the highest frequencies from the string division of the orchestra. Already in this direction the Vitaphone and Phonofilm have abundantly demonstrated that eventually a full Symphonic Orchestra will accompany every worthwhile feature picture throughout its entire length, and be heard at every performance, by the "super show" as well as "de luxe" audiences. One who has heard such accompaniment, as for example "Don Juan" or "Siegfried", can never again be satisfied to sit through such a picture accompanied only by the organ, or what is worse, by an inadequate, poorly trained orchestra, not to mention the lone piano!

As one critic recently said: "In its essence today the motion picture is pantomime combined with music and the two together form the most insidious assault on the emotions yet devised. It is now possible to send out a brilliant score to accompany a brilliant photoplay, thereby supplying a musical accompaniment far more helpful to a picture than the orchestra of the average theatre".

Now comes the time-honored question—"Does the public want the talking picture? Is there room in the field of the silent drama for screen versions which are not all pantomime? Can the picture and the sound which go together so naturally in actual life, and which have been so completely divorced from each other since the beginning of the cinema art, be again brought together in a manner which shall be, if not entirely natural, at least artistic and pleasing?"

If you ask whether the ordinary silent drama with which we are all so familiar can in general be improved by the addition of the voice, the answer is unquestionably "No." Many, and in fact most of the moving picture artists are not trained on the legitimate stage; few have adequate speaking voices—many are incapable of speaking good English.

An entirely new form of screen drama will be worked out, taking advantage of acoustic possibilities not throughout the entire action, but here and there where the effects can be made much more startling, or theatrical, or significant, than is possible by pantomime alone. It is for the scenario writers of the future to see these possibilities, and to work up their situations and scenes around such acoustic effects as can be successfully brought out, rather than to follow the reverse principle of merely attempting to introduce acoustic effects into scenes and situations which were primarily better adapted to the pantomime art.

Quoting further from a former paper—"To reproduce in an artistic and pleasing manner, both musically and pictorially, operettas, entire acts of opera, selections by symphony orchestras, popular bands, the songs of concert singers whom the public admires but is seldom privileged to actually hear—really popularize the playing of famous virtuosos, on piano or violin—there can be, I believe, no question as to the long-felt vacant field which the Phonofilm is destined to fill.

"I intend here only to point out that there lie dormant in the Phonofilm new possibilities for obtaining dramatic and genuinely artistic and beautiful effects, which lie entirely "out of range of the silent drama. It is rather for the progressive and imaginative producers and scenario writers to act on these hints, to evolve something which the public has for a long time, in an inarticulate and half recognized manner, been expecting. To those who have the requisite daring and initiative will come the greatest reward".

I may even venture the hope that Phonofilm will in time elevate the present undeniably low level of taste and intelligence of the average motion picture audience. A rash expectation you will say! But in view of the undoubted advance in relish for good music on the part of the radio public, which statistics amassed by the large broadcasting stations clearly evidence—a result of three years gradual elevation of the quality of their music programs—the above mentioned hope seems based at least on precedent.

Suppose night after night a bit of the best poetry, spoken by trained voices, accompanied by appropriate and lovely music, emanates from the motion picture screen, sumiltaneously appealing to the ear eloquently, to the eye artistically, in title or scene—Would not such presentation, in time, break down the cynical indifference of ignorance—insinuate in the hearts and then into the minds even of "low-brow" audiences a sense first of the melody and then of the genuine beauty of true poetry? I believe so. I am firmly convinced that in time Phonofilm will thus work a very great advance in culture and refinement of the American masses.

So much for the Phonofilm drama. But there are other fields for the useful combination of picture with voice and music which can admit of no serious dispute. Foremost in this category I would place the educational film. Unquestionably most of the educational films, especially for class-room work, could be greatly improve in interest to the audience and in clarity of the lesson conveyed, if their presentation were accompanied by a lucid explanation, delivered in the first place by some authority on the subject who is far more competent to lecture theron than are the majority of the instructors who are presenting the subject or the film to their classes. The proper matter, concise and to the point, will thus always accompany the picture, not too much and not too brief; and information be thus conveyed which the picture alone is quite inadequate to confer.

Similarly in the presentation of scenic films, travelogues, etc. Their interest and beauty can be immeasurably enhanced by virtue of verbal descriptions couched in impressive, and sometimes poetic terms. Consider moreover the appeal of fine pictures of the great outdoors. The sentiments which such awaken can only be adequately expressed by appropriate music, or perchance to the accompaniment of the poem of some great master. All such music and all such poetry can now be interwoven with the picture; and its beauty and its message thereby elevated to ennobling heights, to which the silent picture, however lovely, has never yet attained.

The weekly News Items, which are now recognized as an appropriate part of every film program, can be made vastly more interesting and informative to the audience if, in a few terse sentences, the scene depicted be also verbally described, or the situation, which is frequently or inadequately told by the picture alone, be interpreted by the voice of some well informed, entirely invisible, speaker. Once this form of pictorial news service has been adequately introduced, I venture to say that the average audience will feel that without the spoken accompaniment, these pictures have lost much of their grip, their lively interest.

In the realm of the Comedy immense possibilities for the Phonofilm unquestionably lie. The humor of many ludicrous situations can be screamingly increased if the right words, the right jest were spoken at the right time, in the proper dialect, or vernacular, or tone of voice. Similarly in animated cartoons, where the little animals or manikins can speak their funny thoughts as well as act in their comic ways, the humor of this type of comedy can be readily doubled.

The filming of notable men, characters in the public eye, presidents and rulers, candidates for public office, etc. has already been made many-fold more interesting and genuine to the audience when their voices also are reproduced, instead of the usual more or less inane mockery of their moving lips accompanied by silence. Picture for a moment what the Phonofilm will mean in the future in perpetuating our really great men for coming generations—"How priceless now would be the film reproduction of Lincoln delivering his immortal address at Gettysburg, or of Roosevelt as he stood before the Hippodrome audience at his last public appearance delivering a message to his countrymen, the inspiration of which has already been, sadly lost. Could we now see and hear Edwin Booth as Hamlet; Irving as Richelieu; Mary Anderson as Juliet—for real comparison, not based on treacherous and fading memories, with our present day "great" tragedians! None can deny the need to our present thoughtless generations of frequently seeing and hearing in their exalted moments our really great men reproduced from time to time for the benefit uplift and inspiration of us all. That these great moments in the lives of great men shall not be forever lost to our descendants, is one of the debts which those who come after us shall owe to the film which records both the voice and the presence of the nation's leaders. Already we have in our archives the deathless impersonations of two great Americans recently deceased: Senator LaFollette and Dr. Charles Elliot of Harvard. At any time or place we can now bring back, with a convincing realism that is actually uncanny the force and fiery magnetism of that great Senator from Wisconsin."

It is only since the last meeting of this Society that "Talking Pictures" have come into their own. They are today, for the first time in the history of the industry, being seriously considered by producer and exhibitor.

The remarkable success of the Vitaphone has awakened the dormant faculties of the hitherto skeptical. It has always been a source of wonder to me that the key-men of such a gigantic industry have of late years shown so little vision. It required actual demonstration, a box-office line-up, to awaken them. But such demonstration has at last been made.

THE SPEED OF PROJECTION OF FILM

Richard Rowland*

WE, IN the First National organization, are very much interested in the work and the aims of the Society of Motion Picture Engineers because we know that all of its activities are directed toward the betterment of the film industry as a whole.

It is with particular interest that I note your Standards Committee has tentatively suggested a projection speed of 80 feet per minute and a taking speed of 60 per minute. In this connection I believe that you will be interested to learn that First National is adopting a plan which we believe will, to a large extent, alleviate the evils of improper projection by exhibitors and serve to give the public in general a better and smoother quality of entertainment.

Hereafter the reel bands of every print of our pictures will carry the proper projection speed thereon as a guide to the operator, and this company will do its utmost to impress on exhibitors the importance of proper speed.

The plan in itself is simple. It was advocated by John McCormick, who is in charge of production at our West Coast studios. The greatest difficulty about the proposition is the determination of the proper speed for a given film, because a uniform speed for all motion pictures would not be practicable or satisfactory.

I don't think producers have in the past gone to sufficient lengths in pointing out to exhibitors the necessity of carefully watching their projection speed. Nor do I think that all exhibitors have realized that in running a picture at the wrong speed they hurt its entertainment value tremendously.

Exhibitors in even the smaller towns have, in many directions, developed presentation to a high degree of perfection. They have done wonders in exploitation, and their lobby displays and ballyhoos frequently reach a high degree of excellence. In the larger cities, the musical settings and prologues are often magnificent. In a word, the show is put on in a million dollar manner. But the heart of the whole thing, the kernel in the nut, the basis of the program, the real excuse for the theater's existence—the picture—is too often marred because

*President, First National Pictures.

it is run either too fast or too slowly. In many cases the fault is inadvertent; but in any event it can and should be corrected.

Pictures are cut in accordance with their character. In other words, producers are always "pointing" for either drama or comedy and the tempo is in the speed which best fits the subject. A comedy full of fast action is usually cut to be shown at a speed of from ninety to ninety-five feet per minute, while a slow-moving drama is figured at eighty to eighty-five. Sometimes a picture is filmed in too slow a tempo and must be speeded up in the cutting. Different directors have different methods. One who works slowly will make a picture timed around eighty, perhaps; while others are all for fast action and produce a ninety or ninety-five speed picture. Unless all directors are, so to speak, standardized and work mechanically at the same tempo, this difference will always exist.

When a comedy is cut to run at 90 and is actually run at 80 it becomes "draggy." On the other hand, a drama projected faster than it should be, becomes "jumpy" and the dramatic points fail to register. Titles are another indication. If an audience complains that titles are too long or short, it is because the picture is not being run at the proper speed. The length of titles is determined by the speed for which the picture is cut.

Another thing which we must discount is the fact that, in productions with a highly popular star, the first run exhibitor will often project the picture at a higher rate of speed than is appropriate in order to get more people into the theatre. The producer will sometimes cut the picture to a slower tempo to meet this condition; and the vicious circle is continued.

I am positive that the solution is to be found in the method Mr. McCormick has suggested and which we shall henceforth employ; namely the marking on the reel bands: "This Reel was cut to be run at 85"—or whatever the speed may be.

It stands to reason that, if there is no definite running speed indicated, the exhibitor must rely on his own judgment or that of his projectionist. He no doubt could easily determine the proper speed himself, if he had the time, but if the projectionist has the proper directions before him in black and white, he will be far more likely to follow them.

DISCUSSION

Mr. Richardson: There have been more pictures made to appear absolutely ridiculous by wrong projection speed than by any other one thing. I believe that the method proposed by First National is very practical. I presume there will be no variation in the camera speed in any one individual reel, but certainly it would be a great advance over anything we have done before.

Dr. Hickman: Has Mr. Richardson ever known a case where a picture was projected slower than it was meant to be?

Mr. Richardson: Yes, in Canada I saw a picture run at about 45, as slow as it could be without burning it up.

Dr. Hickman: There has been a plea, a most pathetic plea, for correct projection speed. Will numbers printed on the film reels secure this? Will correct projection ever appear as important to the theater manager as a program timed to box office requirements? The plain truth of the matter is that except for certain key actions, such as walking, eating and dancing, projection speed can vary over wide limits without apparent falsity. I suggest that the burden lies largely with the camera man who should crank relatively faster for those subjects which cannot be projected at prevalent speeds.

It is with deep regret that we note the death of one of our Active Members, Carl E. Akeley, world-famous scientist and noted explorer.

Mr. Akeley died on November 17 last, on the slopes of Mt. Mikeno, in the Belgian Congo, where he was studying and taking motion pictures of gorillas for the New York Museum of Natural History.

PRESERVATION OF HISTORICAL FILMS

Fred W. Perkins*

When Mr. Will H. Hays, head of the Motion Picture Producers and Distributors of America, suggested recently to President Coolidge that the Government of the United States should make efforts toward the preservation of motion-picture films possessing historical value, he brought to public attention a need that has been increasingly realized by those who believe in the value of a visual record of the great events of our Nation and of the world.

We have only to consider how valuable today would be motion pictures of Lee's surrender at Appomattox, of Lincoln speaking at Gettysburg, of the first parade up Pennsylvania Avenue in Washington of the Grand Army of the Republic, of Cornwallis at Yorktown, or of George Washington at Valley Forge, to realize the tremendous worth fifty or a hundred years from now of films showing the inaugurations of Presidents McKinley, Roosevelt, Taft, Wilson, Harding and Coolidge; the appearance before our troops abroad of President Wilson; the scenes of Armistice Day in Paris, New York and Washington; the return of General Pershing and the American Expeditionary force; the funerals of the Unknown Soldier, of President Harding, and of President Wilson; and the many other great events since the motion picture camera became an actuality.

Films of these latter-day events have been made, and most of them still exist. But the whereabouts of some of these films, and whether they will be preserved for the instruction and the inspiration of future generations, are questions which deserve the earnest attention of bodies such as the Society of Motion Picture Engineers. For this Society is concerned, among other things, with the highest uses and greatest public value of the motion picture, and it is difficult to conceive of any greater use than the preservation in life-like similitude of the great figures that move across the screen of human existence.

The need was illustrated less than a month ago in the motion picture laboratory of the U. S. Department of Agriculture. The Washington office of the Panama Canal asked us to prepare for inspection and projection some old films that had been found lying

*Chief, Office of Motion Pictures, United States Department of Agriculture.

in a closet in the Capitol building. We found that the films included ten thousand feet of original negative showing the construction work on the Panama Canal. Decomposition resulting from lack of care had ruined two thousand feet of the negative, and doubtless would have ruined all of it had not somebody stumbled upon this valuable record.

During the World War the Signal Corps of the Army had numerous motion cameramen in the training camps in this country, at the embarkation and debarkation points, and in the camps and fighting zones. The result is 1,800,000 feet of negative dealing with all phases of the war that could be filmed, and including not only pictures of the American troops in France, but in Italy, Belgium, England, Germany, Russia and Siberia. There are such notable scenes as President Wilson speaking to the troops in France; high lights on his two journeys abroad; the more recent events mentioned in the first part of this paper; and the visits to America of the King and Queen of the Belgians, and of Marshal Foch; and there are other precious pieces of negative, showing such events as the Wright Brothers' first airplane flight at Fort Myer, Virginia, in 1909. The officers in charge of this film appreciate its high potential value, and they realize that its custody entails a duty to posterity which becomes more definite each year. But the work of cataloging and periodically inspecting and perhaps renewing 1,800,000 feet of negative is a job of such size that they frankly fear it cannot be done with the personnel and money now devoted to the purpose.

There is valuable historical negative in other custody. The Aeronautical branch of the Navy has pictures showing the progress of naval aviation since 1918; the Navy recruiting bureau has films of the trans-Atlantic airplane flight in 1919, and of the Naval Railway Batteries in action on the Western front; the Army Air Service has a picture of the Round-the-World flight; the National Museum of the Smithsonian Institution has films showing President Wilson's Cabinet, Rear Admiral Fletcher and General Funston, and other valuable pieces of negative, including a short piece, made in 1897, showing two great race horses, Star Pointer and Joe Patchen. The Department of Agriculture has a large amount of negative, some of which is of historical value because of its relation to the development of farming in this country and its pictures of the men who have occupied high positions in the department.

Then in non-governmental custody there is undoubtedly a large amount of valuable material. A complete picture of the important events since the motion picture began could not be made up without assistance from the companies specializing in news and current events films. An undoubted historical value is possessed, also, by many films staged primarily for theatrical purposes, such as "The Birth of a Nation", "The Covered Wagon", "The Four Horsemen of the Apocalypse", "The Big Parade", and many others. The Yale History Series is a better visualization of our country's development than is likely to be made when another hundred years has further mellowed or distorted the facts in the case, and the negatives should be preserved.

There is much variation in the care that is being given to these films. Some are being kept under conditions that are the best so far as is now known. But there are others to which very little if any care is being given. The need is for a central depository for such films—a depository responsible not only for the preservation of films possessing historical value, but for the gathering of all that are now obtainable, and also for obtaining a film record of future great events. The administrative head of such a depository must have a conception of historical values, a knowledge of historical motion pictures now existing, and thorough acquaintance with the characteristics of photographic film. The depository should not be limited by commercial considerations and should have an official governmental status.

The plan as proposed to President Coolidge by Mr. Hays called for incorporating in the projected new Archives Building in Washington at least twenty film storage vaults with a total capacity of 20,000,000 feet of film. It is assumed that adequate laboratory equipment to care for the films thus stored is contemplated. Such equipment will be necessary, and there must be trained personnel to operate it.

The question now comes—who knows how long motion-picture film will last? How long can film records of great events be preserved? As is probably known to all members of this Society, there is no definite answer to this question. The motion picture is still so young that there has not been opportunity to test whether a film will maintain its properties for even a half century. But we do know that some of the earliest motion picture films have been preserved for thirty years or more, and we know that "still" negatives made on film have existed for even a longer period.

The experiences of the laboratory with which I am connected emphasize the extreme importance of proper development, proper fixing and proper washing. In all cases where our negatives have shown early decadence it has been possible to trace the trouble to some fault in the original laboratory processes. But given proper development, fixing and washing, there must still be the most painstaking care to ward off decay and decomposition over a long period. The best information on this phase of the question that has come to me is from the Eastman Kodak Company, which advises that valuable negative be wound on wooden cores having no metal side flanges, be wrapped in black paper, placed in fibre-lined cans, sealed with tape, and stored in the usual film vaults kept at a temperature around 50 degrees F. This temperature is regarded by the Eastman Company as being sufficiently low to prevent decomposition, and the Company also points out that too low a temperature might cause moisture condensation on the films when the vaults are opened. The Eastman Company adds that the films should be examined at periodic intervals, possibly every two years, and should be rewound in a room having a relative humidity around 70 per cent. On such occasions, if there are signs of destruction of the image or if the film is becoming excessively brittle, new duplicate negatives should be made.

With the great quantity of research genius available in this Society and in the motion picture industry in general, and also in some of the Federal and State bureaus, there is possibility of the discovery of better methods of preserving film. For instance, there seems to be a field for research in the direction of devising a chemical coating or a gaseous treatment that would ward off the agents of decay. But the need of immediate action toward the preservation of valuable films now existing does not permit delay in the use of the best methods so far as they are now known. The members of this Society and of all other bodies working for the highest uses of the motion picture will be doing a service for posterity, and for the industry as well, if they will encourage research along the lines suggested; but first and foremost, if they will give the benefit of their opinions and recommendations on the proposal that the Government preserve historical films.

DISCUSSION

Dr. Mees: It seems to me that this movement that the government should preserve historical films is a very important point, and it is not too early to consider it.

A nitrocellulose film is reasonably stable when properly fixed and washed, so that the gelatin coating is free from soluble salts, but nevertheless it will decompose eventually owing to the splitting off of the nitrogen oxide complex from the cellulose molecule. The rate of this decomposition varies enormously with the temperature, so that film that has to be kept for very long periods should be held at as low a temperature as possible. Under commercial conditions, the recommendations made by the Eastman Kodak Company are quite satisfactory. If the film is kept at a temperature of 50°, it will be quite stable for very long periods, but when we are considering the preservation of historical films, we desire to preserve them for periods much longer than those required for purely commercial purposes, and we should aim, if possible, at methods which will preserve the records for thousands of years if our civilization survives so long. Under these conditions, the lower the temperature at which the film is held, the better, and we might reasonably ask that modern refrigerating engineers should arrange to hold the store rooms at a temperature at least as low as zero Fahrenheit. Such films, of course, must be allowed to warm up in a dry atmosphere before they are taken out into moist air, since otherwise moisture will condense upon them, so that between the storage chamber and the outside air there must be a dry, warm room in which the films can be held.

Mr. Richardson: I should like to ask you, Dr. Mees, if you believe decomposition would continue in a vacuum or a relative vacuum.

Dr. Mees: The placing of the film in a vacuum will not appreciably affect decomposition.

Mr. Richardson: I am very much interested in this particular subject. For eight or nine years past I have had this subject up in Washington, but of course it took a man of Mr. Hay's standing to get anything done. I have subject No. 170 of the Biograph Co. which I showed you at the convention last year. That is twenty-five or thirty years old and is, as far as we can see, in as good condition as the day it was made, and it has received no particular care or attention.

I have wondered if it would not be possible, in view of the unknown stability of gelatin through long spaces of time, to transpose the photographs of highly valuable historic films, in reduced form, by means of suitable apparatus, to plates of glass, and thus preserve them almost indefinitely. I would like to ask Dr. Mees whether or not the photograph itself will decompose in the same probable ratio as will celluloid, or at a greater or a less speed?

Dr. Mees: We have no evidence that a properly washed silver image in gelatin ever decomposes, and there is no reason to believe that it would. We know nothing of the action in thousands of years on gelatin except that the sinews of mummies are preserved. I think that a silver image in gelatin on glass would last until the glass devitrified. It is possible that cellulose acetate film will last a long time, but we know very little about it; it is comparatively a new product.

Mr. Richardson: If that is true, there is a new "flexible" glass which will bend to a half circle and spring back again, so that if flexible glass proves to be what it is presumed to be, the problem is solved.

Dr. Mees: My remarks applied to silicate glasses and not to anything called "flexible" glass.

Prof. Wall: I only want to back up what Dr. Mees said. I have some sheet aceto-cellulose made in 1911 which is quite as flexible as it was then, and there are silver images on it and they are sound.

Color cinematography—An exhibition of cinematography in colors was given recently in Paris, according to the Herault system, probably under his patents, 526,602; 526,603; 528,889. Three films were shown; one a costume study, another of scenes in Brittany and the third some pictures of the Legend of the King d'Ys. Some of the scenes are said to have been of great beauty, but care had been taken to avoid rapid movements, as the system is a three-color additive one, with successive projection of the constituent pictures, which would give color fringing with rapid movements. (Sci. Ind. Phot. 1926, 6A, 116.

SOME CONSIDERATIONS IN SPOTLIGHTING

J. H. Kurlander

General

A HASTY review of the history of spotlighting reveals the fact that progress in this branch of light projection has been confined almost entirely to the mechanical side of the problem; the principal exception being a substitution of the electric arc for the earlier sources of lesser brightness.

Until very recently, little had been done regarding even the mechanical construction of the spotlight, the original design, employing a simple plano-convex lens held in variable relation to the light source, having been retained and attention being centered on improving the then existing methods of construction.

A persistent demand on the part of theatrical folk for increased intensities of illumination has naturally been translated into a demand for higher amperage projection devices, since it was assumed, without question, that the use of a higher current would result in a more brilliantly lighted "spot".

In one way, this error, which is a natural one, was unfortunate since it led to the development of the so-called Super-Spotlight which provides a greater intensity of light on flood condition but offers no advantage at all as far as a more brilliantly illuminated "spot" is concerned.

The trend toward high amperage projectors has resulted in a massive type of construction so that there is great danger of this unit assuming cumbersome proportions unless particular care is exercised when designing it.

In its simplest form, a spotlight is nothing more than a mechanical contrivance for holding a lens (usually plano-convex) in variable relation to a source of light. The source commonly employed is the crater formed on one of the electrodes of a carbon arc since the crater possesses high brightness, and what is equally important, can be made to assume a shape such that the projected spot will be circular.

Aside from the necessary adjustments for controlling the operation of the arc lamp, a means is provided for moving it closer to or

* Brenkert Light Projection Company, Detroit, Mich.

farther away from the condensing lens mounted on the front plate of the lamphouse. In this manner, the spread of the projected beam can be varied between certain limits, governed by the amperage, projection distance, lens diameter and lens focal length. Further variations can be obtained by varying one or more of these factors.

A spotlight of the type just described is illustrated in Fig. 1, where it will be seen to consist of a suitable standard, on which is mounted a resistance placed in series with the arc, and a lamphouse containing the necessary arc lamp and condensing lens along with a means for holding a color wheel in position in front of the lens.

The principal features of the device illustrated are the same as those incorporated in the early types.

Fig. 1. A simple form of spotlight for direct operation on 110 volt and 220 volt lines.

Optical Theory of the Spotlight

Spotlights, as ordinarily constructed, are intended for universal service. That is, the spread of the projected beam of light can be varied from as low as 2 or 3 degrees to as high as 40 degrees. The intensity of the projected light, that is, beam candle power, varies considerably over this range of spreads, being very much higher for the low spreads than for the high.

The reason for this is found in an investigation of the optics involved. Briefly, when a light source is placed in front of a lens at a distance equal to the lens focal length, the entire lens becomes as bright as the source, minus the loss in the lens itself. In other words, the lens becomes, in truth, a secondary source of light having an area greater than the original source and a brightness equal to it, minus the loss in the lens. The candle power[1] along the axis of such a simple optical system will then be equal to the product of the lens area by the source brightness by the transmission factor of the lens. That is

$$Cp = kAB \qquad \dots\dots 1$$

The intensity of illumination, expressed in foot-candles, at any point along the axis (up to within a certain distance of the lens) will be the quotient of the axial candle power by the distance squared, measured between the point in question and the edge of the lens. This can be expressed in the form of an equation as follows:

$$E_0 = \frac{kAB}{d^2} \qquad \dots\dots 2$$

Placing the light source at the focal point of the lens constitutes, in effect, an uncorrected form of searchlight projector, the only difference being that a lens is employed in place of the customary parabolic mirror.

The beam spread of such a device, at some distance from the lens, will be equal to the angle subtended by the source from the central point on the lens.

If the source is now placed at a distance greater than the lens focal length so that an image of the source is formed at some definite point in front of the system, the axial candle power, with respect to the point at which the image is formed, will not be changed so that the intensity of illumination at this point will again be expressed by

[1] F. A. Benford, The Parabolic Mirror Trans. I.E.S. Vol X, No. 9, Page 905, 1915.

equation 2. For other points along the axis, however, this equation cannot be used; but it is effective for all points involving actual image formation.

In practice, the source and illuminated plane never form conjugate foci since it is always necessary to move the source slightly closer to the lens in order to obtain a smooth "spot", free of the bluish halo which surrounds the image of the source and which is the result of aberrations in the lens.

If the light source is now moved away from the focal point, so as to approach the lens, the projected beam of light will immediately begin to increase its spread and the intensity across the beam will fall off very rapidly. As this movement is continued the beam spread will become of great proportions, the intensity (of a low value) will diminish slowly, and the intensity of illumination will become quite even over the entire beam.

These changes have a simple explanation although this condition is somewhat more involved than that for "Spot". Briefly, the reason for the decreased intensity is due to the fact that only a part of the lens is supplying light to a given point in the illuminated plane, the remainder of the lens being inoperative as far as this point is concerned. If the entire lens were effective for each point in the illuminated plane, then the intensity of illumination would be identical with that obtained for the "Spot" condition. This is impossible under the circumstances.

There is this much to say concerning the intensity obtained under any given flood condition. If, as the source leaves the focal point and approaches the lens, it is also increased in size by a sufficient amount, then no diminution in flood intensity, as compared with that obtained on spot, would result.

This, however, is possible only to a very limited extent, since in order to fully realize this condition, it is necessary for the source always to subtend the same angle from the focal point. A relatively slight movement of the source toward the lens is all that is needed, therefore, to place this requirement beyond the reach of even a 150 ampere arc so that it becomes impossible of fulfillment.

Nevertheless, there are distinct advantages to be gained in the way of higher flood intensities by expanding the size of the crater, that is, higher amperage, so that here, at least, is one reason—and the only one—for the so-called super-spotlight.

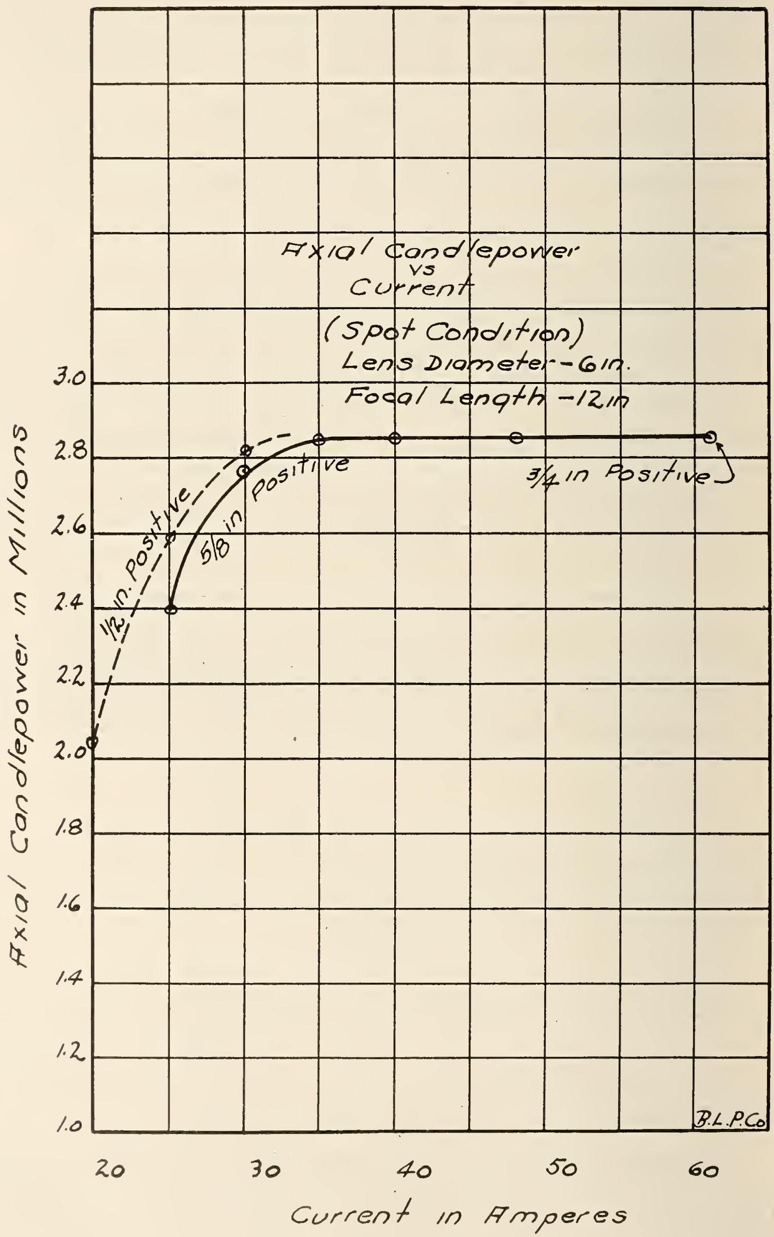
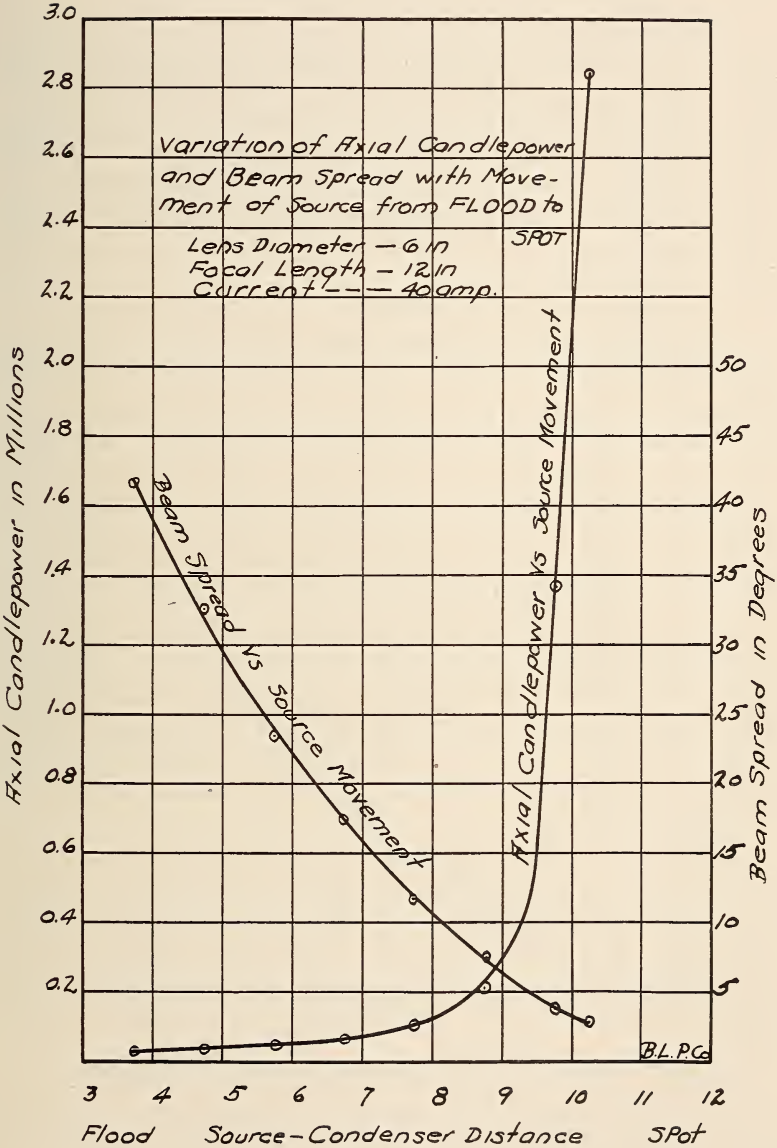

Axial Candlepower
vs
Current
(Spot Condition)
Lens Diameter – 6 in.
Focal Length – 12 in
1/2 in. Positive
5/8 in Positive
3/4 in Positive
B.L.P.Co
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
Axial Candlepower in Millions
20
30
40
50
60
Current in Amperes

FIG. 2.



Variation of Axial Candlepower and Beam Spread with Movement of Source from FLOOD to SPOT
Lens Diameter — 6 in
Focal Length — 12 in
Current — — 40 amp.
Axial Candlepower in Millions
Beam Spread in Degrees
Beam Spread vs Source Movement
Axial Candlepower vs Source Movement
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
50
45
40
35
30
25
20
15
10
5
3
4
5
6
7
8
9
10
11
12
Flood
Source-Condenser Distance
Spot
B.L.P.Co

Fig. 3.

Effect on Axial Candle power of Various Factors

Returning once more to equations 1 and 2, it will be seen from an inspection of the former that no reference at all is made to either size of crater of focal length of lens. The explanation, obviously, is that the beam candle power is independent of either of these factors. In other words, for spot condition, a low amperage arc will provide exactly the same beam candle power as one of high amperage, other things being equal. Also, a long focal length lens will give the same beam candle power as one of short focal length, other things being equal.

In support of the first statement the curve in Fig. 2 is given. It shows the results of tests conducted with arcs of various amperages, ranging from 25 to 61 amperes. An inspection of the curve reveals that on low currents, the beam candle power does not follow equation No. 1, but that from 35 amperes on, there is no change in axial candle-power. The reason for this falling off in candle power below 35 amperes is probably due to the fact that a 5/8 inch positive was used on the 25 and 30 ampere tests with a consequent reduction in crater temperature. In theory, at least, there is nothing to warrant the falling off in beam candle power below 35 amperes.

Tests over a limited range of lens focal lengths showed that the axial candle power remained constant on spot condition. An investigation was made of the variation in axial candle power and beam spread with regular movements of the light source from spot condition to flood. A series of three lenses was used, the current being maintained at a constant value and the photometric readings being taken at a distance of 60 feet.

The results of the tests are shown by the curves in Figs. 3, 4, and 5. It will be observed that each group of curves has a characteristic shape and, also, that lenses of the same diameter, but different focal length, give approximately the same beam candle power for spot condition. Lenses of different diameter are shown to give beam candle powers in proportion to the square of the diameter for spot condition.

In order to observe the distribution of light throughout the cross-section of the beam as the spread increased from spot to flood, photometric readings were taken at regular intervals across the beam for each movement of the source.

Aside from giving information on the distribution of light throughout the beam, this series of tests also permitted a direct com-

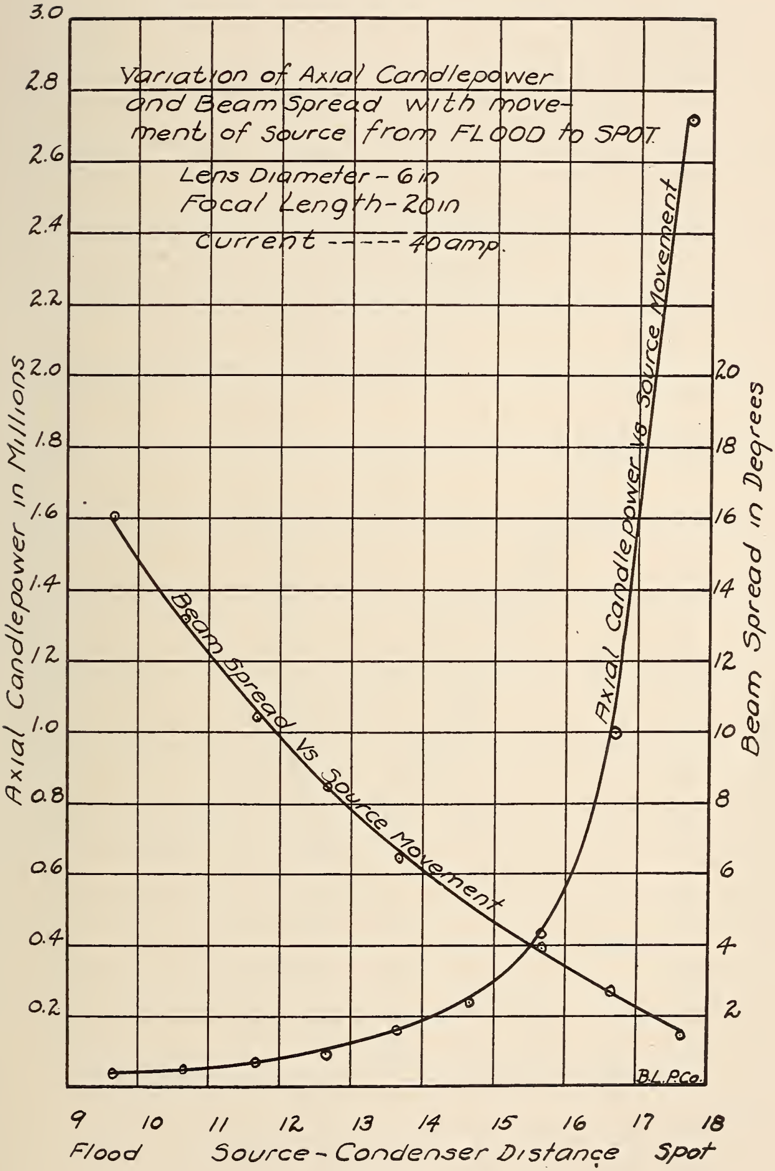
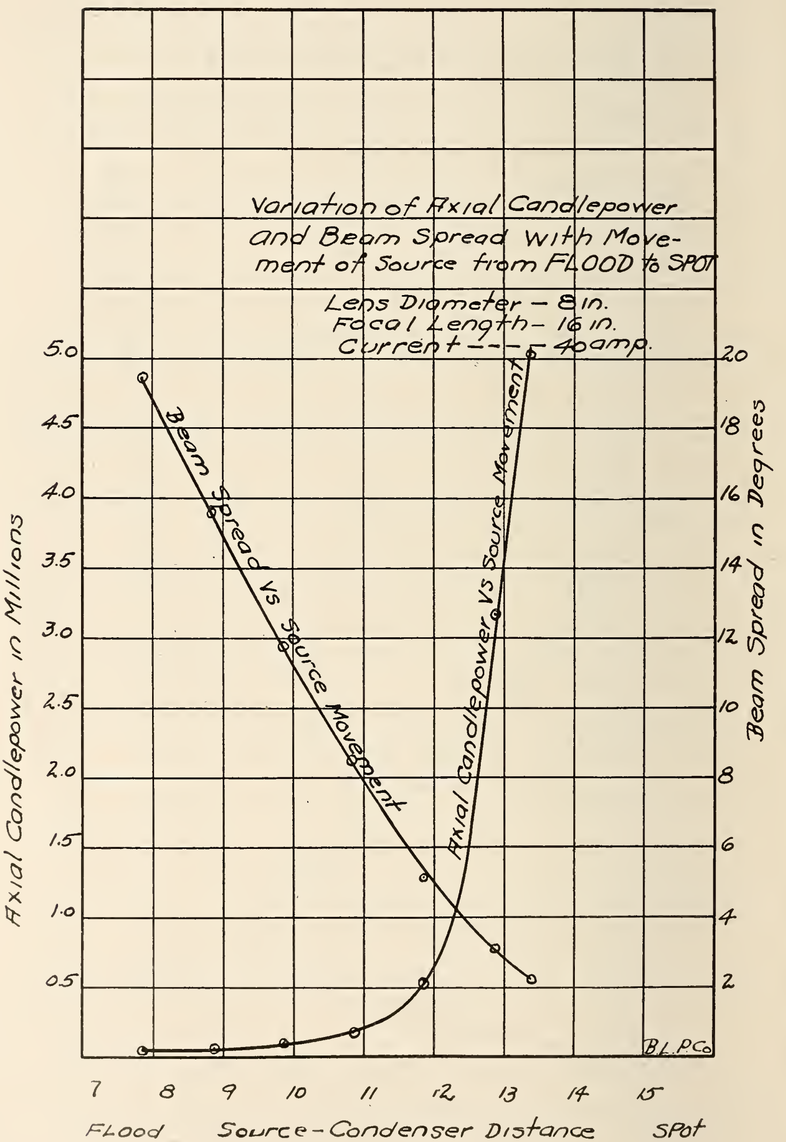

Variation of Axial Candlepower and Beam Spread with movement of Source from FLOOD to SPOT
Lens Diameter – 6 in
Focal Length – 20 in
Current ------ 40 amp.
Axial Candlepower in Millions
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Beam Spread in Degrees
20
18
16
14
12
10
8
6
4
2
Beam Spread Vs Source Movement
Axial Candlepower Vs Source Movement
B.L.P.Co.
9
10
11
12
13
14
15
16
17
18
Flood
Source – Condenser Distance
Spot

Fig. 4.



Variation of Axial Candlepower and Beam Spread with Movement of Source from FLOOD to SPOT
Lens Diameter – 8 in.
Focal Length – 16 in.
Current – – – – 40 amp.
Beam Spread vs Source Movement
Axial Candlepower vs Source Movement
Axial Candlepower in Millions
Beam Spread in Degrees
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
20
18
16
14
12
10
8
6
4
2
7
8
9
10
11
12
13
14
15
FLood
Source-Condenser Distance
SPot
B.L.P.Co.

Fig. 5.

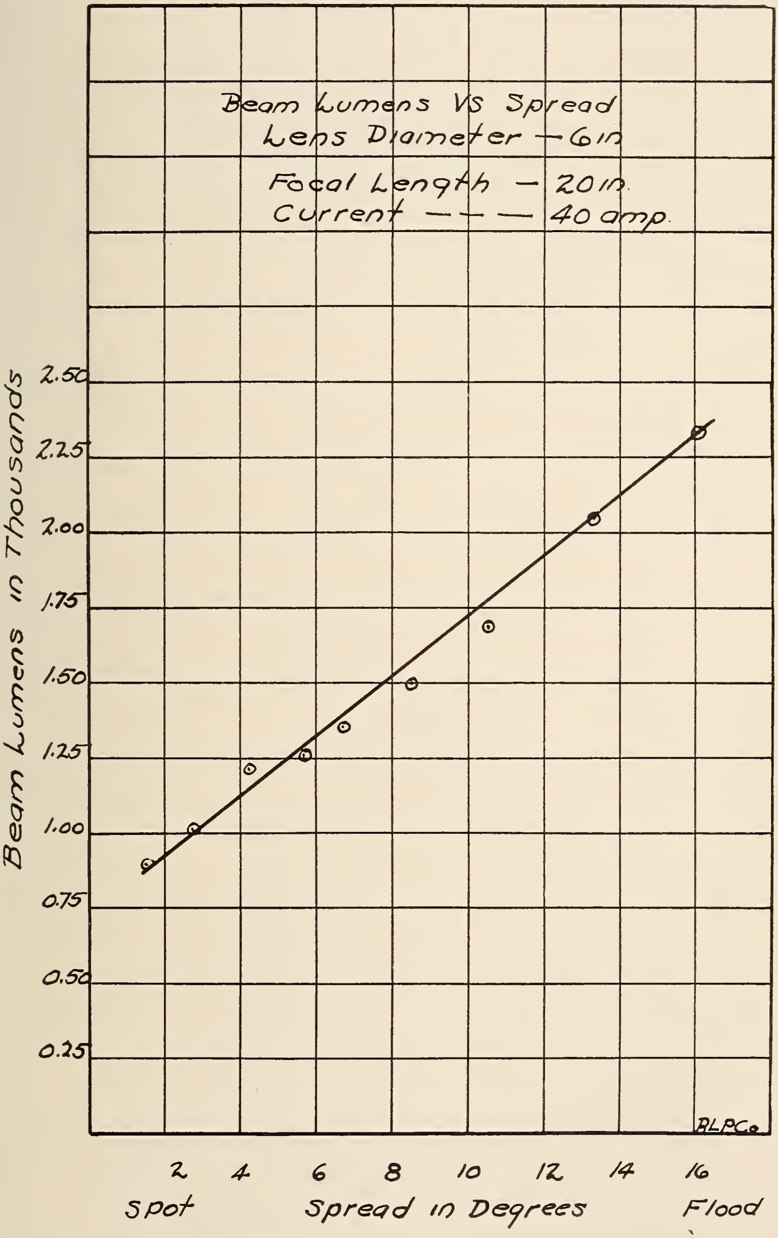

Beam Lumens VS Spread
Lens Diameter — 6 in
Focal Length — 20 in.
Current — — — 40 amp.
Beam Lumens in Thousands
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
2
4
6
8
10
12
14
16
Spot
Spread in Degrees
Flood
BLPCo

FIG. 6.

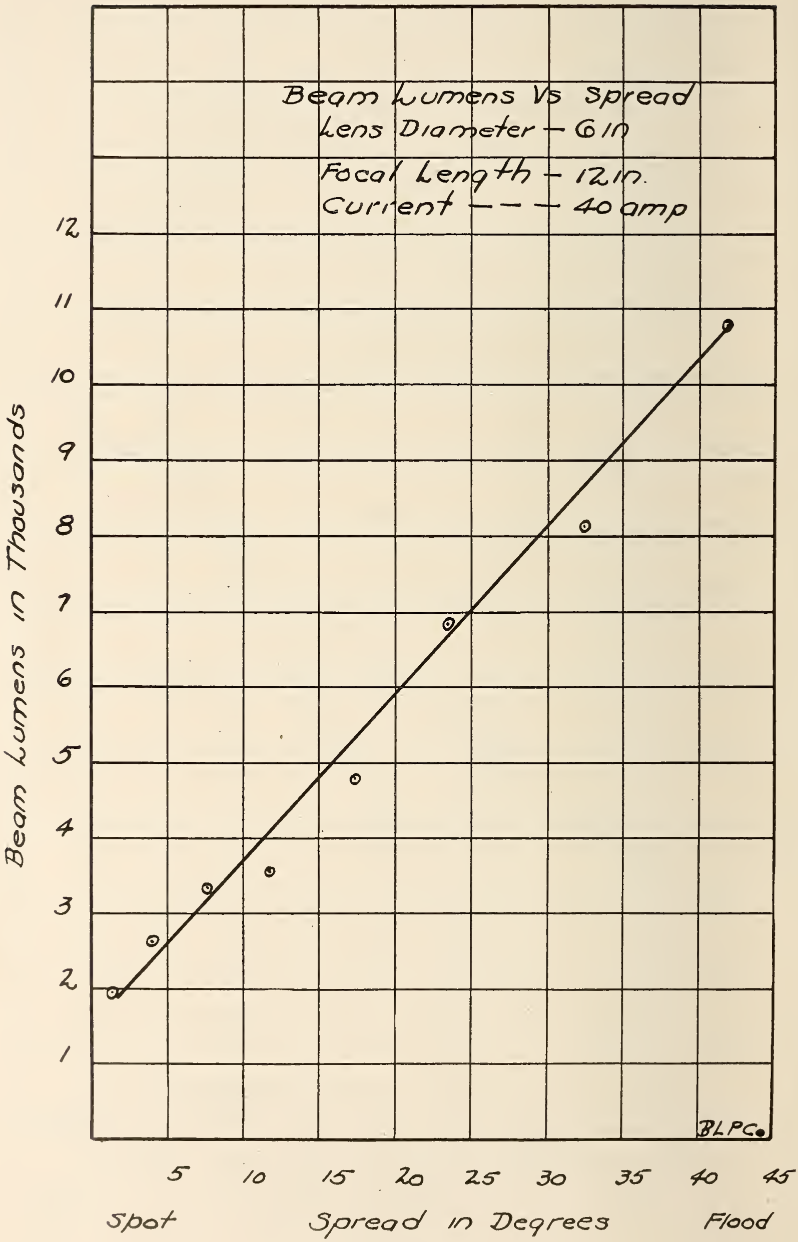

Beam Lumens Vs Spread
Lens Diameter — 6 in
Focal Length – 12 in.
Current — — — 40 amp
Beam Lumens in Thousands
1
2
3
4
5
6
7
8
9
10
11
12
5
10
15
20
25
30
35
40
45
Spot
Spread in Degrees
Flood
BLPCo.

FIG. 7.

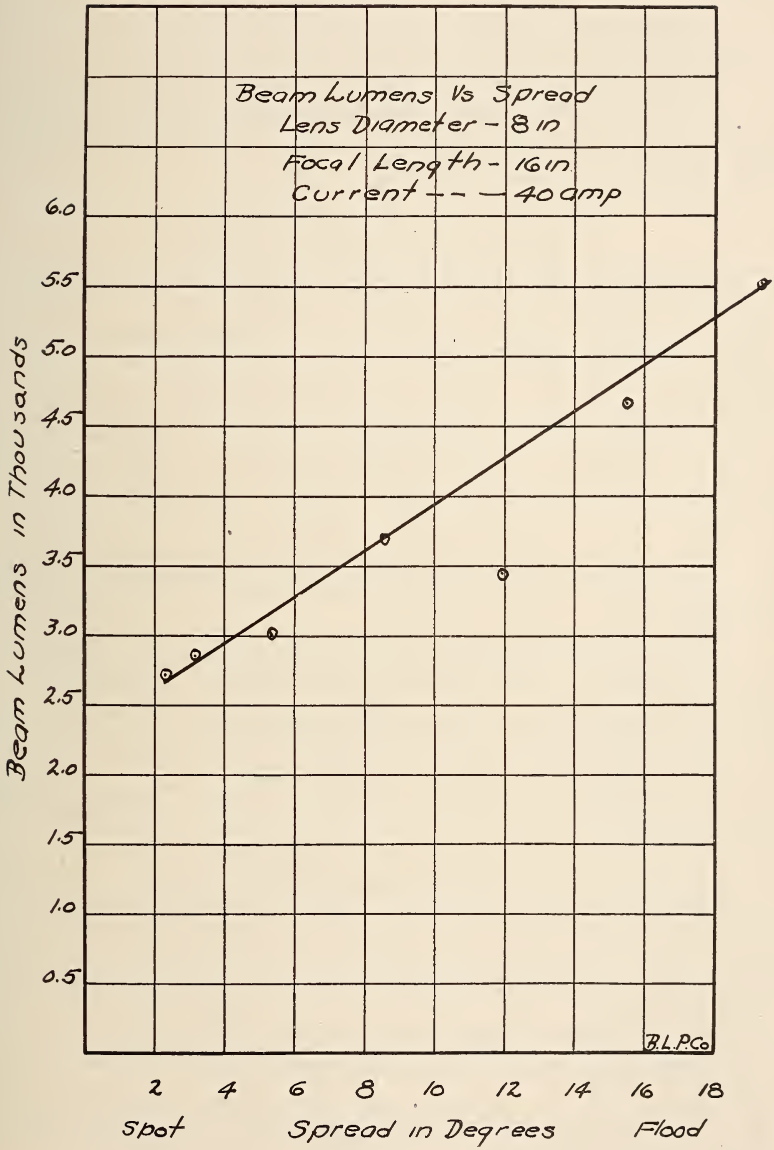

Beam Lumens Vs Spread
Lens Diameter - 8 in
Focal Length - 16 in
Current - - - 40 amp
Beam Lumens in Thousands
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
B.L.P.Co
2
4
6
8
10
12
14
16
18
Spot
Spread in Degrees
Flood

FIG. 8.

putation of the amount of light included within it for each movement of the source. The variation of beam lumens with beam spread for the three lenses used is shown by the curves in Figs. 6, 7, and 8.

The effect of a change in lens focal length on axial candlepower for a flood having a constant spread was next investigated. It was found that the axial candle power appreciably decreased as the lens focal length was increased. (Fig. 9).

Conditions Necessary for Best Results

It is safe to say that the principal function of a spotlight, as ordinarily used, is to provide a small, brilliant spot of light at distances varying from approximately 50 to 150 feet, and a wide spread of light of high intensity for the purpose of illuminating the entire stage when required. The first condition calls for a small brilliant source of light used in conjunction with a lens of long focal length and small diameter. A lens of small diameter is required to reduce spherical aberration which has the effect of increasing the beam spread.

The second condition calls for a large brilliant source, the larger the better, used in conjunction with a short focal length lens having large diameter.

It is obvious that these two sets of requirements are in opposition since no single lens could hope to fulfill both sets satisfactorily. A lens, adjustable both as to focal length and diameter would be necessary and, unfortunately, such a lens is not yet available.

The only practical solution of the problem is to use two lenses, one for each condition. If this were done, then the conditions would be as follows:

On Spot: A brilliant source, an electric arc using from 100 to 150 amperes, used in conjunction with a very long focal length (20 inch) lens of small diameter (6 inch) to offset the effect of the large source area. The resultant spot would be very small, which is the thing most desired, and it would be of the same brightness as the spot obtained from the same type of source used with any other lens of the same diameter. The large source would offer no advantage for spot condition but it would obviate the necessity of expanding the size of the light source when changing to flood condition where a large source is required.

On Flood: A large source, 100–150 ampere arc, used in conjunction with a lens of moderate focal length (16 inch) and large

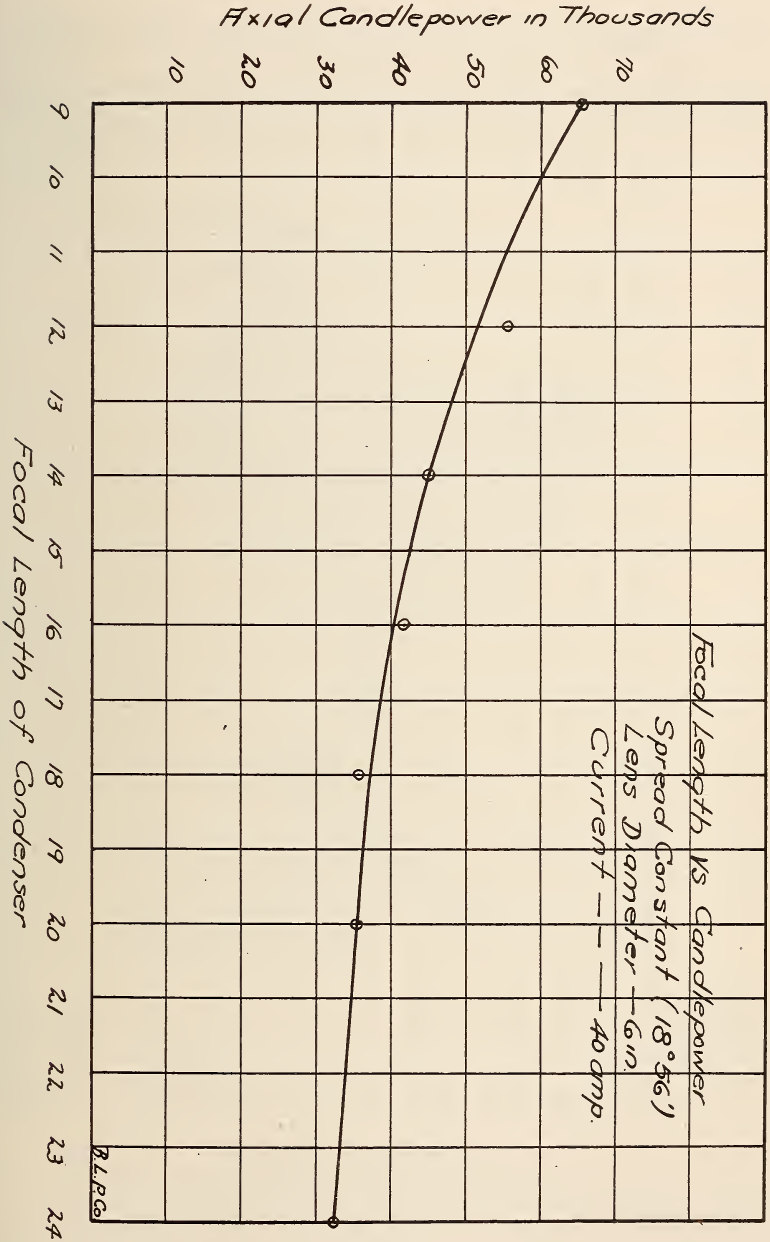

Axial Candlepower in Thousands
10
20
30
40
50
60
70
Focal Length of Condenser
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Focal Length Vs Candlepower
Spread Constant (18° 56')
Lens Diameter—6 in.
Current — — — 40 amp.
B.L.P.Co.

Fig. 9.

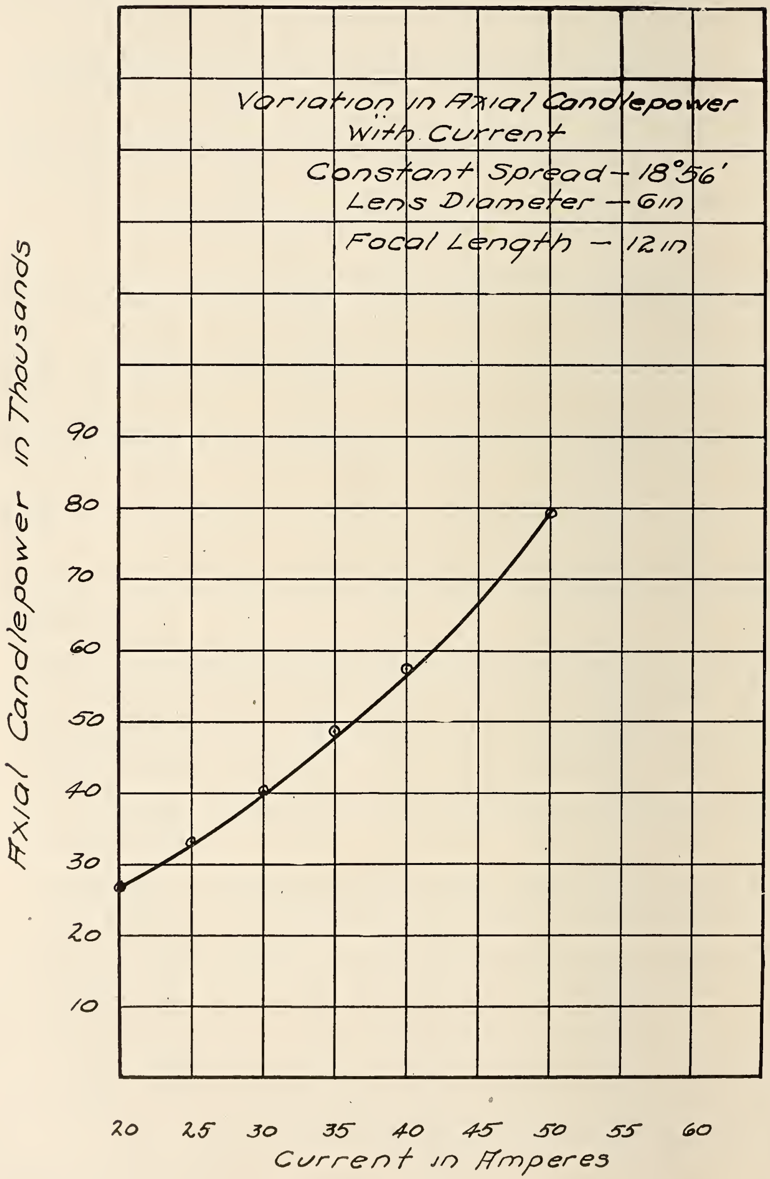

Variation in Axial Candlepower
With Current
Constant Spread — 18°56'
Lens Diameter — 6 in
Focal Length — 12 in
Axial Candlepower in Thousands
90
80
70
60
50
40
30
20
10
20 25 30 35 40 45 50 55 60
Current in Amperes

Fig. 12.

diameter (8 inch). The large source would give increased intensities (see Fig. 10) on the various stages of flood condition; the use of a lens of moderate focal length would give a flood beam of the required maximum spread without sacrificing too much in the way of intensity (see Fig. 9); and the large lens diameter would help the spread of the beam.

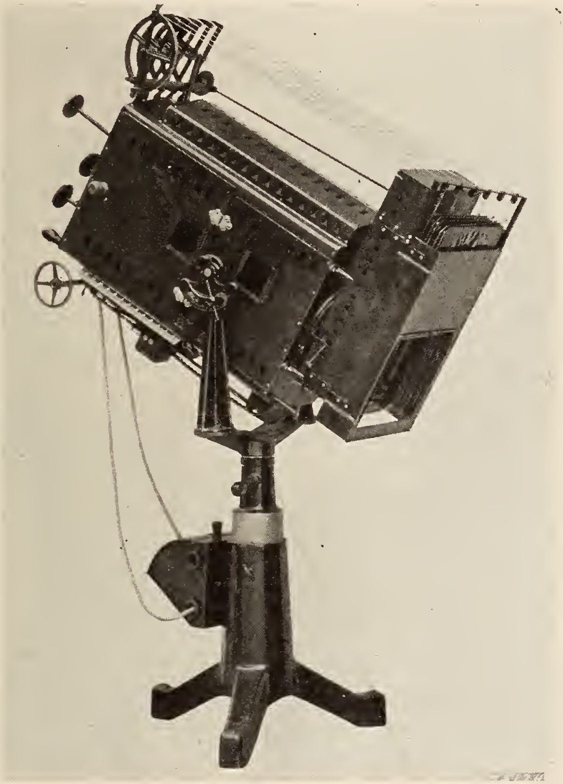


Fig. 11. A true form of spot-flood lamp employing two lenses, one for spot and one for flood, together with a color box for the rapid selection of colored gelatines, an iris shutter, and a pair of framing shutters. All controls are centralized at the rear of the lamphouse and to facilitate rapid operation the arc lamp is counterbalanced, a pre-focus scale being provided for enabling the projectionist to set the lamp in any desired position from spot to flood.

The True Spot-Flood Lamp.

A unit employing such a double lens system would be truly a combination spot-flood lamp since it would perform efficiently under both conditions.

A unit of this type is illustrated by Fig. 11. Aside from the double lens system for producing the best results under the spot and flood conditions, the unit illustrated also possesses a number of mechanical features worthy of note. The most important one is a counter-balanced arc lamp so designed that no matter what position the lamp occupies with respect to the condensing lens, the distribution of weight in the entire lamphouse remains the same. This simply means that it is possible to leave the spotlight head at any angle of tilt without clamping it in position.

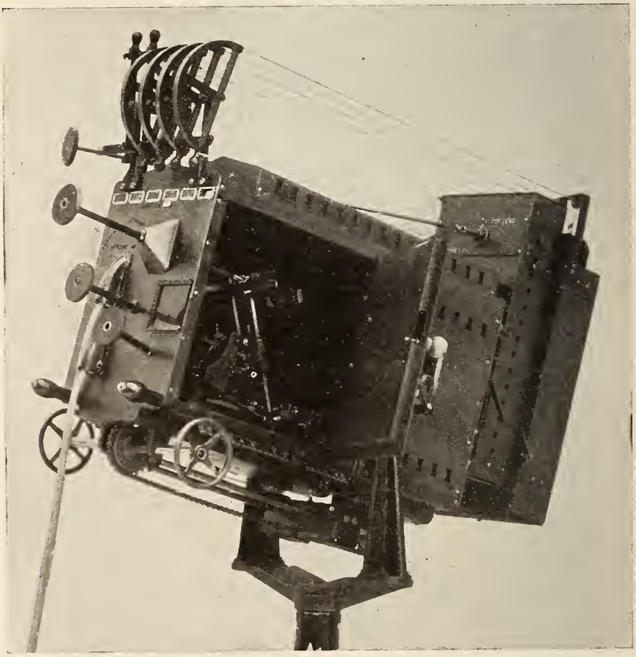


Fig. 12. View showing centralization of all controls at rear of lamphouse. The counter-balance weight, for maintaining an equal distribution of weight in the lamphouse, is shown directly beneath the lamphouse and between the two supporting uprights.

In order to step up the intensity on flood condition, the unit is provided with an arc lamp which has a maximum capacity of 150 amperes. As mentioned before, heavy duty apparatus tends to become bulky and cumbersome unless carefully designed. With this unit, only a light touch of the hand is required to swivel the head on its vertical axis, or tilt it at any desired angle.

It is now common practice, in the case of the so-called Super-Spotlamp, to include as auxiliary equipment a pair of framing shutters, an iris shutter and a color box containing half a dozen or so colored gelatines in suitable frames for the purpose of changing quickly from one color to another. The position of these respective items will be apparent from an inspection of Fig. 12.

From an operating standpoint, the location at the rear of the lamphouse of all controls is of unquestionable value. It should not be necessary for the projectionist to do a promenade of the spotlight in order to operate the various controls.

Future Possibilities

Predictions concerning future occurrences always invite a considerable amount of skepticism so that it behooves the would-be prophet to step cautiously and choose his words carefully. Yet, it seems safe to say that any improvements in spotlights, by way of higher beam candle powers, must be obtained by employing either brighter light sources or larger lenses. Furthermore, the simple optical system now commonly used—a light source in combination with a single lens—precludes any marked increase in efficiency of light transmission so that the use of additional lenses and mirrors can only act to lower the transmission factor of the system with a consequent lowering of the beam candle power now obtainablewith the single lens system.

The use of uncorrected lenses of larger diameter seemingly offers but few practical possibilities except for special conditions so that the only remaining factor is that of a brighter light source.

There are at present three sources of light which have a brightness high enough to entitle them to consideration in modern projector systems. These are:

	Brightness[2] c.p. sq. in.
1. The high intensity arc lamp	318,000–452,000
2. The ordinary carbon arc lamp	103,000
3. The motion picture incandescent lamp	17,000–17,500

Using these figures as a basis for computing the maximum axial

[2]Cady and Dates, "Illuminating Engineering," p. 38, 1925.

candle power obtainable when the respective sources are used with a lens of 6 inches diameter, we arrive at the following values:

	Approximate axial candle power (on spot)
High intensity arc lamp	8,100,000–11,500,000
Ordinary carbon arc lamp	(2,650,000
	(2,800,000 (Measured)
Motion picture incandescent lamp	433,000
Motion picture incandescent lamp (Stereopticon system)	303,000
Motion picture incandescent lamp (Stereopticon system—8 inch diameter condenser)	540,000

It is necessary to call attention to the fact that both the high-intensity arc and the incandescent lamp cannot be used in conjunction with a single lens for spotlight purposes since the tail flame of the first and the irregular filament of the second result in the formation of a spot which is unacceptable to performers and projectionists. A form of stereopticon system is required by both.

Summary

Spotlight projectors as commonly constructed are intended for universal service. That is, they are used to provide a high intensity of light over a very small angle, ranging to a relatively low intensity of light over a very large angle.

This range of service can be divided into two distinct conditions, spot and flood, each possessing different optical characteristics as follows:

On Spot. The axial candle power is determined by the brightness of the source, the area of the condensing lens, and the transmission factor of the lens.

Other things being equal, the size of the light source, its total candle power, has no practical bearing on the axial candle power. In other words, a 35 ampere arc will provide the same axial candlepower as a 150 ampere arc.

Other things being equal, the focal length of the condensing lens has no practical bearing on the axial candle power. The same axial candle power will be obtained regardless of lens focal length.

The axial candle power will vary directly as the source brightness.

The spread of the beam will, in general, be equal to the angle subtended by the light source from the central point on the condenser.

The size of the light source controls only the size of the spot.

The axial candle power is proportional to the square of the diameter of the condensing lens.

On Flood. The candle power in any direction is determined by the brightness of the source, the area of the condensing lens *effective in that direction,* and the transmission factor of the lens.

The size of the light source has an important bearing on the candlepower in any direction, within the limits of the beam, any increase in the first being attended by an increase in the second and vice versa.

On extreme flood, if the light source size is progressively increased, the flood candle powers will also increase until a point is reached where the axial candle power on flood will equal that obtained on spot. Further expansion of the light source area will be attended only by a widening of the beam. In other words, flood intensities greater than that obtained on spot cannot be obtained, other conditions being the same.

It is safe to assert that this condition will never be realized with arc lamps because of the extremely large source required. To realize it completely the light source would have to subtend the same angle from the principal focus of the condensing lens as the lens itself.

The lens focal length bears an important relation to the beam spread and, consequently, to the candle power.

In general, for the same beam spread, long focal length lenses will provide a lower axial candle power than shorter ones. For the same source-condenser distance, long focal length lenses will provide greater beam spreads of lower axial candle power.

The candle power in any direction will vary directly as the source brightness.

In general, the diameter of the lens has no effect on axial candle power, this being determined by the brightness of the source, its distance from the lens, and the focal length of the particular lens. The beam spread will be increased as the lens area is expanded, and vice versa.

In general, the beam spread is determined by the focal length of the condensing lens, the location of the source with respect to this lens, the diameter of the lens, and to a certain extent, the size of the light source. The beam spread, for any condition can be easily determined by the use of a graphical method and simple calculations.

DISCUSSION

Mr. Samuels: Are there any results from experiments with mirror arcs?

Mr. Kurlander: There is no increase in light; if anything there is less light with mirror arcs. The fact that an arc operates successfully for a motion picture projector is no reason why it should operate in the same manner for a spotlight when the conditions are different.

Mr. Richardson: I believe this is the first real examination that has ever been published concerning the spotlight. Incidentally, I noted one statement made by Mr. Kurlander which I am sure cannot be correct. He said that the brightness of the lens was equal to the brightness of the source, which cannot be true unless the entire light from the source is incident on the lens. He said the focal length of the lens has nothing to do with the candle power of the beam. I doubt that, because the focal length of the lens has much to do with the distance of the light source from the lens in order to get a certain size spot. What you have said amounts to saying that it does not matter how far away the light source is from the lens, or I have misunderstood your meaning.

Mr. Kurlander: No, I meant what I said. It is not necessary to intercept all the light. The lens is a secondary source except that it operates over only a limited angle. It is as bright as the source itself minus the 10–20% loss in the light. If you stand in the beam and look at the condenser through a dark glass, you will see on spot condition the entire lens filled with light. As you walk across the beam, as soon as you leave the true spot, you see the lens only partially filled with light, and that is why the intensity drops off at the edges. If the source is pushed closer to the lens, only a small area of the lens is effective in any one direction. Only about three-quarters of a square inch of area is operating along the axis on extreme flood.

Mr. Richardson: So you make all your measurements on the axis?

Mr. Kurlander: No, all over, as shown by the curves.

Mr. Richardson: Then, what does the axial brilliancy have to do with it?

Mr. Kurlander: It is the maximum under any condition, especially on spot—the axial candle power. If the source size is varied it will vary only the size of the spot. You are not changing the fundamental equation that brightness is equal to the candle power times the aperture of the lens, times the transmission factor of the lens.

Dr. Gage: In 1911 when I first went with the Corning Glass Works, a study was made of the optical conditions of the lenses as used for railroad signal purposes. The railroads use a corrugated lens, which has nothing to do with the argument. At the focus of the lens was placed a kerosene flame so that the lens appeared to be entirely filled with light. Under these conditions, the calculation of the beam candle power along the axis followed along the same lines as Mr. Kurlander outlined here, so I can endorse from experience in another field the correctness of the optical principles which Mr. Kurlander has described.

Mr. Hill: Mr. Kurlander spoke of the difficulty of using a high aperture condenser for spot work on account of spherical aberration. I would like to ask Mr. Kurlander if he has tried a corrected lens?

Mr. Kurlander: No, I have not, but I intend to as soon as I get a chance. The spherical aberration varies as the square of the diameter of the lens. I did make a simple test on an 8 in. diameter 16 in. focal length lens on a projection distance of 60 ft., which gave a 28 in. spot, and a 6 in. lens gave a 22 in. spot. This assumes a smooth spot, one acceptable to the profession, but as for making tests on corrected condensers, I have not done that yet.

Prof. Wall: What shape lenses are you using?

Mr. Kurlander: The standard plano-convex lens, that is, a single lens as commonly used for spotlighting.

Prof. Wall: If you insert a meniscus convex lens between the arc and the lens, would you not include more light?

Mr. Kurlander: It would not be of use without increasing the lens aperture.

Mr. Porter: I think that last statement is born out by tests in our laboratory. Mr. Kurlander reported 500,000 beam candle power with the incandescent spot. We made up a spotlight using a meniscus lens and got up to 800,000 c.p.

Mr. Kurlander: That figure with an 8 in. lens and stereopticon system was calculated in the formula, and I gave those figures more or less as an indication of proof that the formula was correct and to show what could be expected from other sources. The tests on the ordinary arc agree very well with the calculated candle powers. In connection with the small spot and small lens, there is a great demand in theaters to get the smallest spot obtainable, which cannot be got with an ordinary spotlight at any appreciable distance. It is out of the question, so the important consideration in a spot is to get one as small as possible. By using a small diameter lens, you sacrifice candle power to get a small spot; you are getting a little better than half the candle power that you get with an 8 in. lens.

A technical school of photography and cinematography has been founded in Paris on the initiative of some of the leading photographic manufacturers and professionals, under the patronage of the Minister of Public Instruction and with the support of the City of Paris. M. L. P. Clerc, the editor of Science et Industries Photographiques, one of the leading technical journals of the world, being the Director. The cinematographic course extends over 2 years, each of three semesters and 38 hours instruction per week. The syllabus, which may be obtained from M. Clerc, 87 Rue de Vaugirard, Paris (VIe) is extraordinarily complete. During the first year electrical and mechanical principles and their application to projection are fully dealt with. Nor is actual practice neglected, for each subject is also simultaneously covered by the student. In the second year studio lighting with actual exercises is followed by camera work and laboratory practice. Students are permitted to confine their attention to projection, laboratory or camera work. There is no age limit for students, who must provide their own materials. Diplomas are awarded, after examination, and certificates to those unable to gain a diploma. A four-story building houses the school and is fitted with all the necessary studios, laboratories, etc.

SOURCES OF LIGHT

P. R. Bassett*

THE purpose of this paper is to treat the subject of light sources in motion picture work from the physical point of view. A number of interesting and useful papers on light sources based on other considerations are contained in our Transactions, and an attempt will be made not to repeat data that has been covered in these previous papers. In this discussion the physical causes of light production rather than the sources of energy or types of apparatus will be used as a basis. There are a number of ways in which matter may be agitated so that it will produce light. The agitation or disturbance may be obtained by a variety of means; the flow of electric current, chemical action, such as combustion, etc. The different types of light production are principally as follows: fluorescence, phosphorescence, luminescence, solid incandescence, and flame incandescence.

In motion picture work, fluorescence and phosphorescence play no part because of their low brilliancy. The only instance that I know of fluorescence being utilized in motion picture studios was the early attempts at correcting the color value of mercury vapor arcs by painting the reflectors with rhodamine, which fluoresced with a red glow, the color which is missing in the mercury vapor light. Fluorescence is the light given off by certain materials when a shorter wave-length falls on them. The short wave-length is absorbed by the material and re-emitted as a longer wave-length, but the brilliancy is always comparatively low. In motion picture work there are two requisites for light sources—actinicity for the studios and brilliancy for projection. It is possible only by the last three methods of light projection to produce a brilliancy or actinicity suitable for motion picture work. In the studios the very first sources of light used depended on luminescence. The mercury vapor arc and the white flame arc were the two original light sources and both are luminescent sources. Luminescence is always produced by a gas or vapor into which sufficient energy is introduced to tear apart or ionize the molecules and atoms. This action is accompanied by light and when the energy concentration is great, the light from such a source can be very bright and very actinic. Since ionization is the cause of this luminescence, the spectrum is not continuous but is distinctive of the

* Sperry Gyroscope Co., Brooklyn, New York.

elements or materials which are energized. Therefore, by proper selection of materials, actinic lights or lights of various colors may be produced. Mercury vapor is in common use for two reasons; first, because of its actinicity and, secondly, because of the ease of vaporizing it and forming an electric arc in the vapor.

In the white flame arc, cerium and other rare earths are chosen because their spectrum is not only actinic but has so many lines scattered through the visible spectrum that it gives a clear white or blue-white appearance.

These light sources are still the main sources of studio equipment, but strange to say no matter how much energy is concentrated in a luminescent source, it has not yet been possible to bring it up to sufficient brilliancy to be useful as a source of light for projection.

The actual intrinsic brilliancy of a mercury vapor arc is only from 0.01 to 0.1 c.p. per sq. mm. The brilliancy of the carbon arc flame is from 0.01 to 0.1 c.p. per sq. mm., and of the white flame arc from 1 to about 6 c.p. per sq. mm., so when we turn to the projection end, we leave the luminescent sources and utilize the light produced by solid incandescence, the tungsten filament of an incandescent lamp or the hot carbon crater of an electric arc. Compare the intrinsic brilliancy of these sources with the figures mentioned for the luminescent sources. A gas-filled incandescent lamp runs in brilliancy from 10 to 30 c.p. per sq. mm., the crater of the carbon arc runs from 100 to 200 c.p. per sq. mm. Solid incandescence, such as produced by these sources, is temperature radiation from the solid material caused by the agitation of the molecules of the material jostling each other but not breaking down or ionizing as in the case of luminescence. Therefore, the spectrum of the incandescent sources is continuous, having all wave-lengths and is not characteristic of the material but is characteristic of the temperature to which the material is heated. When a solid body is heated, it radiates this heat. As the temperature increases, the radiation increases as the fourth power of the temperature and the maximum wave-length of the radiations shifts from a point in the extreme infra-red toward the shorter wave-lengths. As the wave-length of the radiation shifts toward the shorter waves and gets down to the visible spectrum, first appear the red radiations or longer wave-lengths of the visible spectrum. An object heated up to this temperature is called red-hot. As the temperature increases, the radiations increase in intensity and the maximum shifts further toward shorter wave-lengths. We therefore pass through the stages of yellow-heat to white-heat. Ordinarily when we say a thing is white-hot, we consider that such a temperature is the maximum obtainable but this is not so. The only reason that it has been considered so is that by the time the temperature is raised to white-heat, all materials either melt or vaporize and it is, therefore, impossible to find anything which can be raised to a higher temperature and still give solid incandescence. Instead, they vaporize and fall back to giving luminescence and, therefore, much lower brilliancy even though the temperature is still high or higher. But, in considering the high-intensity arc, we can actually demonstrate an incandescent source of light which is actually at a temperature hotter than white-hot and which could be called blue-white heat.

We are now all familiar with the high-intensity arc. It has become well established, both in the studio and in the projection field. It holds a unique position in each field in that it has not so much displaced or crowded out other units as it has made possible the extension of accomplishments and improvement of results in both fields. For instance, in the studio, it has been in a large measure responsible for the new technique of large sets, one of the outstanding achievements of the American motion picture. In the theatres it has made possible the typical modern de luxe motion picture house of a seating capacity from 3000 to 5000, and gives projection in these large houses which is more satisfactory even than in many of the smaller houses.

It must be admitted that for many years we used and talked about high-intensity arcs without having a complete understanding what the source of light was. All the early literature on these arcs refer to a ball of gas or vapor in the crater. Further study of this arc, however, has disclosed a remarkable story and one which fits into the scheme of light production, which we are considering in a very surprizing way. The secret of the extremely high brilliancy of the high-intensity arc is neither luminescence nor solid incandescence. It is flame incandescence.

The history of the development of light sources is written entirely around flame incandescence up to within the last hundred years. The original pine knot with its red and smoky flame, which our ancestors carried as their only source of light, was flame incandescence. The candle, the rush-light, the oil lamp, and the acetylene lamps, such as used on the early automobiles, are the progressive steps in the improvement of flame incandescent sources, and each step is an increase in the temperature and, therefore, the brightness of the flame. The incandescence of all of these flames is due to the fact that they contain very minute, what might be called colloidal particles of free carbon, which are produced by the chemical action of combustion and which are heated up by this action to a temperature so that they glow. These particles are not as small as molecules and, therefore, they do not ionize but actually give out temperature radiation of the same quality as a carbon rod or filament would give out at the same temperature. These colloidal flame particles are usually burned with the oxygen of the air by the time they reach the top of the flame and pass off as a gas, carbon dioxide. Hence, we are not ordinarily aware of the fact that they are solid material. The smoky or sooty flame, however, is the give-away. Since, when the carbon supply is too great or the air supply too small for complete combustion, these flame particles cool off as they pass out of the flame without being burned and appear as ordinary soot or lamp black.

The first intimation that the high-intensity arc was peculiar and not like other arcs, as had been taken for granted, was due to the occasional occurrence of soot from the flame coming from the positive crater. This soot can be produced very densely by overloading the carbons or by causing the crater flame to push out sidewise into the cold air, so that it is cooled so rapidly that combustion is not complete. Upon collecting this soot and examining it and testing its qualities, it is found to bear a strong resemblance to ordinary lamp black. We might call this new product the "electric lamp black," as it is the first known method of actually producing lamp black from an electric arc. The ordinary carbon arc will not soot, it will hiss and carry on in all other ways but it cannot be made to produce an incandescent flame, and, therefore, cannot be made to soot. The actual cause of the incandescent flame in the high-intensity arc, therefore, cannot be laid alone to carbon. It is due to a chemical reaction between the carbon and the cerium salt with which the core is impregnated. This chemical reaction takes place at a very high temperature right at the bottom of the crater. The carbon and the cerium unite to form carbide.

Cerium carbide is a rare but not unknown compound which has a boiling point so high that it has never been actually determined experimentally, but has been estimated at about 4800°C. This is some 600 or 700 degrees higher in temperature than it is possible to heat carbon, because carbon volatilizes at 4100°. We, therefore, have the solution of the secret of the high-intensity arc. The flame consists of colloidal particles of cerium carbide heated up to a temperature 600 to 700 degrees hotter than carbon can possibly be heated, and making an incandescent flame quite similar in its properties to the ordinary incandescent flames of burning organic material.

It is extremely interesting in looking at the progress of illumination to notice how for thousands of years the only class of illumination used was the flame incandescence which progressed through the centuries from the pine knot to the acetylene automobile headlight. Then with the coming of electricity, flame incandescence was entirely deserted. Progress switched to solid incandescence with the coming of Edison's carbon filament lamp, and the tungsten lamp; in the gas field the Welsbach mantle supplanted the fish-tail flame, the street arc lights gave most of their light from the solid incandescence of the craters of the hot electrodes. Electricity also brought luminescent sources. The flame arcs, the old yellow flamers that used to hang in front of the first motion picture theaters, the mercury vapor arcs, the Moore tube which had a short-lived popularity, and now the Claud Neon tube, are all luminescent sources. Flame incandescence was actually deserted. Now, however, through the high-intensity arc, electricity and the incandescent flame have joined hands and produced a unique illuminant, the most brilliant yet known and a very important member of the motion picture family which has played its share in the progress of the industry during the last six years.

DISCUSSION

Mr. Palmer: Can you suggest, outside of the electric arc, any light source which would be suitable for photographing at night?

Mr. Bassett: There is one thing that immediately comes to mind, namely, the use of chemical flares. When burned at night, they appear tremendously bright, but actually when measured the brilliancy figures are found low as compared with the electric sources of light. It is a matter of burning enough flares and keeping down the wind on account of heavy smoke. I do not know of any other source which is satisfactory.

Mr. Richardson: If electric action is supposed to be from positive to negative, why should it appear strongest from negative to positive in the electric arc? Another thing: has your organization done anything on the possibility of turning out a projection lens to decrease the harshness of the high intensity light?

Mr. Bassett: In regard to removing some of the blue hue of high intensity projection, we have investigated the matter of yellow tinted condenser lenses but not the projection lenses. It would seem a more difficult thing to apply the color correction to the projection lens than to use some form of filter such as the K2 which has been done successfully.

With regard to the direction of current flow in the arc, you can generally consider that any electric phenomenon occurs from minus to plus. When positive and negative were originally named it was really a mistake; it would have been better to name them the other way. Almost all the electric carrying particles are negative electrons. The current is carried across by negative electrons which jump to the positive, so that the flow is minus to plus.

Mr. Manheimer: May I ask Mr. Bassett at what current value does an arc become a high-intensity arc? On one slide it seemed to me that at approximately 80 amperes and over the arc became of the high-intensity type. I am under the impression that there is a projection arc machine on the market which consumes approximately 25 amperes and is considered a high-intensity arc. I should like to know more about this.

Mr. Edwards: Has a chemical analysis been made of the white ash in the lamp house from the high intensity arc?

Dr. Hickman: If you increase the amperage of an ordinary carbon arc, Mr. Bassett has told us that the brightness goes up to 200 and beyond that it is merely the carbons which get hotter. He has told us that the high-intensity arc uses the same materials and for some mysterious reason with increasing current up goes the intensity. There must therefore by some subtle difference in the design which changes the crater from an ordinary arc to a high intensity arc. Why is this difference in design never described?

Mr. Bassett: Mr. Manheimer asked about current. It has been a problem to obtain high intensity at low currents. We used used to think that 75 amperes was low; we forced it down to 50, and now we can make a satisfactory 35 ampere high intensity arc, and there can be high intensity arcs at lower currents, but I should not call them efficient.

The phenomenon of high intensity does not appear suddenly at any special current but becomes easier to obtain as the current is increased. The first appearance may start at 20 amperes and reach a fairly efficient point at 50–70 amperes; it is a question where we break the curve as to what we call high intensity or only an overloaded flame arc. The logical point is where the brightness exceeds 200 c.p. per sq. mm. With ordinary carbons if normal current is applied to them you will obtain about 100 c.p. per sq. mm. If high currents are forced through the flame carbon it will go up to 200 c.p. brightness and may go up higher and show a high-intensity effect. To maintain this effect permanently and steadily however, the factors of quality of electrodes, method of burning them, etc., become of prime importance. An ordinary flaming carbon carrying an overload current in an ordinary lamp would not give a usable high-intensity arc.

With regard to chemical analysis of the deposit from an arc, it has been analyzed and is almost entirely cerium fluoride with occasionally cerium oxide, which is yellow, while the cerium fluoride is white.

There is nothing more injurious in the fumes or deposit than in ordinary fine powder or smoke.

THE EFFECT OF MOTION PICTURES ON THE EYES

Guy A. Henry*

A FEW years ago a public official in addressing a national welfare organization made the following startling prophecy:

> "Motion pictures will be extinct in ten years. The public realization that they are ruining eyesight will lead to a demand that they be abolished. Within ten years I predict that there will be no more motion picture shows in America. By that time they will be barred as a pernicious evil. They will be dropped by common consent for the common good as other useless things have been dropped in the past."

If this dire prophecy had found fulfillment this conference would not be in session today. Had this prediction been made in the early days of the moving picture when poor photography and faulty projection with distressing flicker prevailed, there would have been some grounds for it; but such wonderful changes have taken place in the production of motion pictures and in their showing that in recent years there has been no just cause for serious apprehension as to motion pictures harming the eyes, providing attention is given to certain conditions.

Under favorable conditions moving pictures do not cause serious eye fatigue, but it must be borne in mind that several very important elements are necessary to make these "favorable conditions."

We will reverse the order in which attention is usually given to problems in industry and instead of first considering the mechanical factors we will consider the human element. Industry is inclined to develop the mechanical and neglect the man—to strive for mechanical perfection failing to consider the physical fitness of the individual. This fault in industry applies generally in regard to production problems.

In the subject now under consideration instead of the physical fitness of the wage earner it is the physical fitness of the customer, the individual in the audience, to which attention is directed.

Why is it with the great improvements in the production and exhibiting of motion pictures, so many complain that the movies hurt their eyes, and why is there prevalent the idea on the part of many that motion pictures are injurious to the eyes? This is a matter of concern to the industry—what is back of this complaint? Does the

*General Director of the Eyesight Conservation Council of America.

fault lie in the technique of production or mechanics of reproduction? No. You have accomplished wonders in the mechanical. Such remedy as is needed there is easy of accomplishment and lies in the simple correction of practices in the theater. To these I shall refer later. What, then, is the major cause for the complaint that the movies hurt the eyes? Let me tell you—if the viewing of motion pictures such as are shown in the better class of moving picture theaters results in eye discomfort, headaches, or drowsiness the chances are that it is the eyes of the observer that are at fault rather than the moving pictures themselves.

Movies don't cause eye trouble but frequently do reveal the existence of eye defects.

Unfortunately, most of us have physical defects of vision—by this is meant that the eye itself is defective to an extent that causes vision to be less than normal or that the individual has good vision only through an extra exertion which causes eyestrain.

The great majority are unaware of impaired vision and do not know that theirs is less than the full measure of the most valued of the senses. Many others do not understand that a considerable degree of the vision they do enjoy is gained only through nerve exhausting eyestrain.

It must be borne in mind that viewing motion pictures is distance vision and the eye is being subjected to no greater burden than viewing distant objects under ordinary conditions, with this difference, of course, that there is the effort of constant and prolonged concentration in viewing motion pictures which does not obtain with the use of the eyes ordinarily in observing distant objects.

It is this element of concentration which causes motion pictures to act as a test of distance eye endurance and serves in many instances to indicate the presence of ocular defects.

In considering the possibility of eyestrain resulting from motion pictures, we must remember at all times that distance vision is involved—not near vision.

It is not the use of the eye for distance vision that is the cause of most of our eye troubles, but it is the demand of modern living conditions which puts such a greatly increased burden upon our eyes for near work. It is the innumerable adjustments required of the eye at close range under unnatural indoor life that aggravate the evil consequences of ocular defects, whereas looking at motion pictures is long range vision. Consequently, if the viewing of motion pictures under proper conditions results in eye discomfort, it is quite a sure indication that such a person has a defect of vision which is responsible for the eyestrain he experiences and he should attend to his eyes rather than condemn the movies.

If the eyes of the observer are normal for distance vision or corrected for refractive defects the owner should not experience discomfort in viewing motion pictures provided certain other conditions prevail.

This brings us to the consideration of certain mechanical factors having to do with the effect of motion pictures on the eye which are namely:

1. The photographic quality of the film;
2. The projection of the film;
3. The screen from which the film is reflected;
4. General conditions in the auditorium.

With the remarkable advance in the moving picture industry and the improved methods of photography and of film manufacture, there has been attained a high standard of quality in this country in the production of motion picture films.

Worn films which produce streaks and spots of light or induce other objectionable defects of course should not be tolerated and I understand that practices adopted by the film exchanges have brought about a careful inspection of films which precludes the possibility of a worn or defective film being circulated for use in moving picture theaters. This is a precaution which the industry has wisely inaugurated. It is beneficial from every standpoint and is a practice which should be encouraged and its application widened to include the field outside of the motion picture theater.

Proper projection is an important factor in the elimination of eyestrain and eye discomforts and here again great improvements have been made in the mechanical field.

Flicker will result in eyestrain even for a normal eye because flicker affects the involuntary muscles, which control the action of the iris regulating the size of the pupil, and the effort of the iris to rapidly contract and dilate the pupil, in response to the stimulus of the rapidly varying light produced by the flicker, will quickly produce a condition of extreme fatigue. Flicker was formerly a most serious defect in motion picture projection, but development of projection mechanism has reduced this objectionable feature to a minimum when, the projection mechanism is kept in proper condition.

It, of course, is important that the machine be firmly mounted so that there will be no vibration to affect the smoothness of the reflection from the screen. Any unsteadiness or jerkiness will produce eyestrain as a result of the abnormal burden placed upon the extrinsic muscles of the eye in their effort to keep the eyes in alinement with uncertain and erratic movements of the pictures on the screen.

Occasionally a lateral movement of the picture on the screen is perceptible which the layman will attribute to fault in the projection, whereas it is due to unsteadiness of the camera in the original taking of the picture. Such defect is seldom noted in other than out door location where there is naturally, more difficulty in gaining a firm placing of the taking apparatus than in the studio.

This lack of stability places a burden upon the muscles controlling the movement of the eye from side to side, but fortunately it is not common.

In no circumstances should an operator ever permit the light from the projecting apparatus to strike the bare screen. The sudden transition from the comparatively low illumination reflected from the screen as a result of the light passing through the film to the relatively bright light would be blinding in effect and decidedly harmful to the eyes of the spectators.

Eyestrain will be produced if the picture on the screen is out of focus. Involuntarily, the eye will try to compensate to make the picture more distinct—will try to overcome the fogginess and clear up the indistinct view. This holds true especially with regard to captions.

There is involved here I believe an interesting bit of psychology. One will unconsciously try to compensate in some way, to overcome lack of definition in motion pictures, whereas, with a still picture which may be hazy one recognizes the fault as uncorrectable by personal effort and instinctively does not try to clear it up.

I have wondered at times if possibly the eyes of some of the operators who were focusing the machines were not defective and that this was responsible for lack of definition on the screen. Accurate vision is certainly required of the one who is responsible for deciding such an important matter.

In respect to the relative position of screen and seats certain conditions are important.

The observer should be a t least 20 feet from the screen, because any distance less than 20 feet will bring into use the accommodation and convergence of the eyes imposing the conditions of near vision.

A joint committee on Eyestrain in Moving Pictures appointed by the Illuminating Engineering Society of London, a few years ago, gave careful consideration to various conditions conducive to eyestrain and as a result of their study certain provisions were recommended regarding the relative position of the eyes of observer and the screen.

The angle of elevation in respect to the direct line of vision is important. The recommendation provides that seats should be so placed that to observe the top of the picture the eyes need not be raised more than 35 degrees from the direct horizontal line of vision. If the seats in the front row comply with this recommendation it is evident that all other seats in the auditorium will afford a satisfactory range of vision in the vertical plane.

Another important recommendation pertains to the lateral angle of vision, i.e., the angle to the side. The recommendation provides that at the far edge of the screen, (the edge most remote from the observer) the angle formed by the screen and the line of vision should not be less than 25 degrees.

Certain general conditions in the auditorium are of decided importance and the outstanding need here is for attention to the general illumination of the room while the picture is being shown. Most theaters are darkened more than they need be with the result that there is set up a condition of undesirable contrast. The human eye does not function to its best advantage in the dark or in looking at a fairly well illuminated object when the eye itself is surrounded by darkness. There should prevail as high a degree of general illumination as may be consistent with securing clear and easy vision of the picture.

Too low illumination causes dilation of the pupil to an abnormal degree and provides a corneal area which does not permit of focal accuracy and which tends to distortion of outline. To partially overcome this there is induced segmental action of the ciliary muscle governing the focusing of the eye. Such muscular action can be attained only by great effort.

There is also strain of the iris muscles resulting from the prolonged dilation of the pupil, and another objection is that the varying intensity of the light reflected from the screen requires constant iris action more difficult of accomplishment than under normal dilation.

There is constant conflict between the extreme darkness surrounding the eye and the light reflected from the screen. Under such a condition the eye is not only more susceptible to the natural varying intensity of the light from the screen, but the adaptability of the eye is lowered and the slightest flicker or movement is more noticeable and detrimental.

Extreme darkness is better for petting than perception. I am not advocating a degree of illumination that would detract from the romantic environment but rather an effect equalling starlight, a necessary element to make complete a midsummer night's dream or, better, a condition approaching that of moonlight, Cupid's one most effective allurement.

Neither may it be possible to afford sufficient illumination to enable one entering from the brightly lighted foyer to find a seat conveniently without first waiting until the eye adapts itself to the sudden transition.

It takes but a minute or two for the eye to become adjusted to the darkened theater and if one will wait he may avoid the embarrassment of trying to occupy a seat already completely filled by a large lady in a dark dress who has no desire to share the slightest part of it with an entire stranger.

The illumination of the auditorium should be gradually reduced from the rear to the front and all light sources so modified as to prevent glare, especially those which may fall within the spectator's range of vision. A faulty shade leaking a little light in the orchestra or over the organ will be a source of annoying glare, for even though the intensity of the reflected light from the screen may be much greater, the direct light by reason of the dark background will by contrast, be blinding in effect and harmful to the eye.

The decorative scheme of the auditorium naturally affects the general illumination. Gilt and silver even in subdued light may produce annoying reflections and, in some instances, these are responsible for an unfortunately low degree of lighting.

A flock of gilt or silver cupids floating around for decorative effect may produce annoying reflections when the lights are dimmed. Instead of reducing illumination to obscurity it would be better to invest them with a coat of dull bronze or to so cover them as to permit of a proper degree of general illumination.

All surfaces which might produce reflections should be guarded against, light brackets on walls and chandeliers should be dull finished.

At intermissions or changes in program when the general illumination is turned on, the current should be carefully gauged and the auditorium gradually brought from a state of semi-darkness to full light. A sudden or too rapid turning on of light is not only irritating but decidedly harmful to the eye.

Investigations reveal that managers of picture theaters have no scientific way of determining whether or not the general illumination of the auditorium is what it should be and, in fact, this is governed by the judgment of the management which may take into consideration certain factors and entirely disregard others of equal or greater importance. A scientific study should be made of this problem and standards of illumination established for the guidance of the managers so that they may be sure that a matter so important as the general illumination of the theater during the showing of the picture is scientifically correct and that the eyes of their patrons are not being subjected to strain. In fact there should be developed a special code of illumination for motion picture auditoriums which will cover a field, which is too important to be left to the judgment of individuals.

Before leaving the subject of general conditions pertaining to the auditoriums I wish to mention one cause of headaches, no doubt frequently attributed to the eyes, which in no way has to do with light effects or eye defects. I refer to the ventilation—lack of proper ventilation will quickly produce discomfort, dullness, headache and other symptoms similar to those resulting from eyestrain.

The various conditions mentioned as important in relation to eye comfort are as easy of fulfillment in the cheaper theaters as in the better equipped. For the most part it calls for only a little thoughtful observation and attention to obvious details.

I have endeavored to present those things dealing with the effect of motion pictures on the eye and while specific references have been made to desirable practices in the motion picture theater that which has been said applies with equal force to another field in which you are concerned, namely, motion pictures in the so-called educational domain or non-theatrical.

Here, unfortunately, there does not obtain a helpful and beneficial control of films, attention to proper projection and other details. Films may be run until they become so worn as to show light streaks and spots which cannot help but cause eyestrain. Projection apparatus is not firmly mounted or becomes defective producing jerky motions of the picture and harmful flicker. Attention is not given to general conditions under which pictures are shown.

How to accomplish the much needed correction is difficult of solution, but it is a matter of concern to the industry and a responsibility of the industry to provide for proper supervision of the condition of films and projecting machines.

Possibly this may be best brought about through a control of distribution and an educational campaign which will acquaint those handling and showing films in the schools, colleges, churches and elsewhere, with the importance of observing proper precautions to avoid deleterious effect upon the eyes.

There is a great opportunity for your industry to further the cause of eye care not only by attending to those things in respect to the production and exhibiting of motion pictures which have to do with eyesight conservation, but there is also the great opportunity afforded through the medium of the screen to educate the public to the importance of eye care by visualizing, in the many ways which are possible through the moving picture, the story of conservation of vision.

In fact, it may be regarded as an obligation of the motion picture industry to actively participate in the educational campaign which is being conducted in the interest of the public.

As you serve so will you prosper. You contribute richly to the entertainment of the public through the eye and if with your great opportunity you employ that opportunity to present the sorely needed message of eye care, you will be serving the cause of humanity and enhancing the comfort and enjoyment of that which your industry offers to the public. You have the greatest medium in the history of man for visualizing to your enormous audience throughout the land a message of great human interest and of great benefit. It is your opportunity and your privilege to point the way not only to greater enjoyment of the entertainment which you offer, but to the greater enjoyment of life itself through better vision.

DISCUSSION

Mr. Richardson: Mr. Henry made one statement that needs amending. I have made some study of the distance at which a spectator must be from the screen to avoid a too wide viewing angle. You have placed this at 20° while I have placed it at 20° from a 16 foot picture. If you look back through the proceedings of the Society, you will find a paper presented by myself on the difficulties of standardizing theater illumination. To my mind it is almost impossible of accomplishment because of the enormous variation of the conditions. For instance, if you adopt a certain screen illumination and a certain foot candle auditorium illumination, which factors interlock, when the maximum viewing distance is 80 feet, and establish the same thing in a theater when the maximum viewing distance is 170 feet, as it is in the Capitol, it would set up an enormous eyestrain for those in the near seats. Automatically, in order to avoid eyestrain, you must increase the illumination of the screen as viewing distance is increased. I believe the front end of the theater should be of relatively low illumination intensity as compared with the back end. As you have said, undesirable contrast must be avoided, and I am of the opinion that there is still much work to done along this line. I am well aware of the work the Eastman Kodak Company has done in establishing the relative contrast between the surroundings of the screen and the screen itself but this would have to be changed in different theaters. I do not think, Mr. Henry quite realizes the difficulties encountered when we undertake to standardize theater illumination.

Mr. Henry: With respect to the 20° angle, I did not mean to convey the idea that it was fixed. I said it should not be *less* than 20°. The other matter of the attempt to try to establish a standard should not to my mind be an attempt to establish a standard of illumination but a minimum of illumination recommended to reduce the excessive contrast so frequently existing in motion picture theaters. As far as it being a difficult problem to solve, I should imagine that is what this Society is for.

Dr. Mees: It seems to me that it will be quite impossible for the Society to lay down specific rules for the operation of motion picture theaters. This can never be done; all that can be done is to lay down general rules for the expert to work out. What the motion picture theater owner should do is to employ motion picture engineers to tell him what to do. A motion picture theater owner is not an engineer but an expert in the art of entertainment. He should have engineers to tell him what to do with regard to screen brightnesses and auditorium brightnesses, and he should employ them before completing the theater. Mr. Henry's plea therefore, it seems to me, should be modified to read that we should establish standards as a result of research which the engineers can apply in the theaters, and I imagine that is what he meant. A good deal of work has been done on this subject and I think we should continue to prepare papers on the subject and then discuss and summarize the results.

Mr. Henry mentioned the question of educational projection. That has been actively in our minds for the last two years. The Eastman Kodak Company has undertaken to make a collection of motion pictures suitable for use in teaching, and we had to face projection conditions. We believe we shall have to provide not only suitable apparatus but field workers to show the teachers how to use them. We must demonstrate it personally and keep an eye on the schools afterwards, and this we are proposing to do. We are also proposing to make some pictures dealing with hygiene for the instruction of children in that branch, and I think we shall be very glad to have Mr. Henry's co-operation on this. A picture dealing with the care of the eyes could be and should be made of value in the schools.

Mr. Henry: We shall be glad to do all we can.

Mr. L. A. Jones: There is one statement made by the speaker on which I should like to have further information. He stated that the continued long adaptation to low levels was fatiguing due to the continued large size of pupil. I wonder if he meant that. I question that statement because it seems to me there is no eyestrain under outdoor night conditions. The eye pupil may be wide open without causing fatigue. It is simply a matter of the difference of brightness in the field of vision which, as he stated, does cause considerable eye fatigue and is injurious and annoying.

I should like to answer, partially at least, Mr. Richardson's criticism of the extent to which recommendations have been made for the illumination of theaters. As a matter of fact the problem is a very complicated one and we do not at the present time know enough about the subject to outline a complete solution. We do, however, have some knowledge of certain factors and can make certain broad general recommendations. Data are available which indicate the maximum contrast in the visual field which can be tolerated without producing undue visual fatigue. We can state definitely that contrast should not exceed a certain value. The permissible contrast depends to a great extent upon the adaptation level at which the eye is operating. Hence, in order to make a definite recommendation as to permissible contrast it is necessary to know at what level the eye will be called upon to operate. It is necessary therefore to devise some means of measuring the adaptation level of the eye in a motion picture theater. Work on this problem is at present in progress, and we hope in the near future to be able to publish some definite data on the subject.

The brightness of a surface is independent of the distance at which the surface is viewed. I do not mean by this statement to imply that Mr. Richardson is wrong when he says that the most satisfactory screen brightness depends upon the viewing distance. There is little doubt that the adaptation level at which the eye operates depends upon the angular dimensions of the illuminated area, hence upon the distance of the observer from the screen. If this is true it follows that the brilliance of the picture, that is, the magnitude of the sensation, depends upon the viewing distance. It should be remembered that this statement applies only to a special case in which the visual field is composed of a relatively small bright area of variable size, depending upon viewing distance, surrounded by a relatively large dark area.

Mr. Henry: With regard to the area of the pupil and the use of the eye outdoors at night: under those conditions we are not looking at the lighted screen and do not have a source of light at which we are looking. Furthermore, out-of-doors at night we are not looking for detail—the eye is not sharply in focus. In viewing motion pictures the eye is in focus, vision is concentrated and with the very much dilated pupil you have exposed a corneal area in connection with which there is faulty refraction. There is induced a segmental accommodation which is very fatiguing.

Dr. Mees: Those of us who have had experience for years in working in dark rooms would not agree. I have worked in the dark, and many of my colleagues have worked in the dark, and there is no eyestrain in dark rooms at low levels. I agree with Mr. Jones that eyestrain is a matter of contrast.

Mr. Henry: In a motion picture theater you are looking at a bright screen, the pupil is dilated due to the surrounding darkness and additional dilation and contraction is required due to the varying intensity of light from the screen.

The situation you refer to in a dark room is not the same as that in the theater because you do not have the varying conditions nor equivalent contrasts.

Dr. Mees: My point is that it is not the dilation of the pupil but the tension.

Dr. Hickman: I do not believe that the picture theater should be dark in the front and light in the back, but until a model theater is built I cannot prove it. The speaker and one or two others have suggested that the eyestrain increases as the pupil opening increases, and Mr. Jones and Dr. Mees have favored the opposite view. With all due respect to them, I don't think this is so. We have a certain facility of vision dependent both on lens perfection and the retinal receiving structure at the back. In a bright light the retinal resolving power is high, and since the lens is able to work at small aperture, any natural defects such as astigmatism are not noticeable. As the illumination is decreased, the iris enlarges and the eye must now make a muscular effort to correct lens defects. This causes eyestrain. At still lower levels of illumination such as in dark rooms, it is the retinal structure that fails to resolve, and it becomes almost immaterial how we focus the eye. The muscles of the eye release their effort and enter into a second condition of rest.

Lately I have had to do some continued writing in a room not overwell illuminated and though able to see perfectly have had severe eyestrain. I then imported a table lamp which gives a vile condition of simultaneous contrast, which, I am told should produce severe eyestrain. Actually it has banished it entirely because the eye is now able to work at such small aperture that no effort is required for critical focus.

Mr. Briefer: I think there is a good deal of merit in the suggestion that the professional man while working in a dark room or examining pictures before release is in a different situation from the average person entering the theater. Very few people know how to use their eyes, and I think a good deal of attention has been given to this indirectly. There is a tendency to return to the fade-out and fade-in between scenes.

Some time ago the Society recommended the adoption of the black border around the picture so as to reduce the jumpiness of the screen picture.

This should be adopted for educational pictures as one means of reducing eyestrain.

TRICK PHOTOGRAPHY

William V. D. Kelley*

EVERY large film producing organization now has its trick and miniature departments. These are used to cut down costs, produce impossible situations, create dramatic suspense without danger to the actors, to save moving from one part of the globe to another with a cast, and to enhance comedy situations.

A prominent director said, when shown a scene showing Miss M. in a taxicab threading her way through the crowded traffic of Fifth Avenue, "I wondered how that was done, for I knew Miss M. had not been out of Hollywood."

It was done in this manner. Miss M. was photographed in the conventional taxi-cab of the studios against a non-actinic background, so that on the negative nothing was exposed but the taxi-cab and Miss M. A second negative was made of Fifth Avenue, New York City. These two negatives were then fitted together, so that the audience saw on the screen the taxi, bouncing along, threading its way through the receding views of Fifth Avenue and its traffic.

In the same manner situations are created where a trapeze performer falls from the swing to go hurtling through space, to fall and be seen in a cage of lions, where actors are crushed under mountains of snow, with timbers and roofs falling in a burning building about the performers, where the performers appear in a street scene of China or Australia or London and never move from the studio lots of Hollywood.

The new Handschiegl process, which will be demonstrated with a reel of shots already made, is thought to be an improvement over the Williams' system, heretofore largely used by the producers.

The inventor, Handschiegl, says:

> We photograph two negatives of any objects or group of objects against a blue or a black background. One negative is developed and especially treated, thereby making it a mask. When using a black background we intensify the negative and when using a blue background, we make it black on one negative and white on the masking negative by special use of filters. We can successfully put shadows of people or objects into a scene with the action by using the blue blackground. Our process is the only one with which shadows can be put on with the action. After making our mask under this process, we use a special camera or optical printing machine and place the one negative, which has been developed and treated, in front of the other negative which has the same image photographed

*President, Kelley Color Films, Inc., Hollywood, Calif.

but undeveloped, thereby masking the undeveloped image with the developed image. We photograph any still scene, painting miniature or stock set, or in fact any object around an object already photographed on the original negative. The use of the blue background is made possible only through the use of our twin image camera. The claims we make that our process will revolutionize production are not based upon theory but upon actual demonstration. There is hardly anything that cannot be done photographically under this process and the results obtained are such that they defy detection on the screen.

More specifically, I would add that the new system involves the use of a twin camera, that will make two matched negatives at each exposure.

One negative is made so as to give the performers a clear unexposed background and this negative is held undeveloped.

The second negative exposes the performers and the background, so that a positive may be made, which will be over-printed or developed so as to act as a silhouette of the performers only.

This silhouette negative, when placed in the camera in front of the first negative, acts as a mask, so that a set, a miniature, a drawing, or any conceivable action or scene may be exposed into the background.

If an orange colored background is used, one negative insensitive to orange, will photograph only the performers. The second negative, being red sensitive, will photograph the background, giving in the resulting negative, the performers against a background.

A variation of the above system seems to be interesting a lot of inventors for there is at the present time an interference in the Patent Office involving Handschiegl, Williams, Pomeroy, Crespinel and Mitchell. Two matched negatives are made of the action against a non-actinic background, which may be black. One negative is held undeveloped. The other negative is developed and treated so as to convert it into a silhouette of the action. This silhouette is placed in front of the first negative to prevent additional exposure in those parts already exposed and the second exposure made. This allows the making and delivery of an original negative.

Various ways of converting the second negative, or a print from it, into a silhouette are available and doubtless the different inventors describe them in their patent applications.

Both of the above systems are based on the idea of making two matched negatives.

Frank D. Williams has a patent, used and developed by him and utilized by many of the large producers, in which only a single negative is required.

Handschiegl has a single negative system for which a patent has been asked. I am permitted to describe it. The negative of the action against a non-actinic background is exposed, developed but not fixed and dried. This negative is insensitive to red under normal conditions. A red filter over the printing lamp permits a positive to be made from the negative without fogging it. From the positive a dupe negative is made, and this dupe is developed and intensified until it becomes a silhouette of the first exposure. Now this silhouette is placed in front of the negative and the second exposure made.

This idea of showing you a few samples of trick work only came up just before I left Hollywood so that the demonstration is limited to a few feet, kindly supplied by Mr. Handschiegl. In the examples shown the female figure moving about in the picture was photographed against the colored background, while the backgrounds are cut out negatives from productions.

Copies of previous issues of the "Transactions" that are still available may be obtained on application to the Secretary, Mr. L. C. Porter, 5th & Sussex Streets, Harrison, New Jersey.

Nos. 1 & 6 are out of print. The prices of the others are as follows:

Nos. 2 to 9, $0.25 each; Nos. 10 to 15, $1.00 each; Nos. 16, 17, 18, $2.00 each; Nos. 19 to 26, $1.25 each.

The supply of some issues is limited.

PANCHROMATIC NEGATIVE FILM FOR MOTION PICTURES

LOYD A. JONES AND J. I. CRABTREE

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  Dark room illumination;
    General;
    Inspection lights;
  Use of desensitizers;
  Processing solutions.

PHOTOGRAPHIC materials, from the standpoint of their sensitivity to light of different color, may be divided into three classes: *ordinary*, *orthochromatic*, and *panchromatic*. Those belonging to the class designated as *ordinary*, or *blue sensitive*, are sensitive only to blue and blue-green and do not respond appreciably to green, yellow,

*Research Laboratory, Eastman Kodak Co.

or red. As typical of this class may be mentioned Eastman Commercial Film and Eastman 40 Plates. By the use of suitable sensitizing dyes photographic materials can be made which, in addition to the blue sensitivity of the *ordinary* type, are sensitive also to green. They are usually referred to as *orthochromatic* and the Par and Super Speed Motion Picture Negative film fall in this class. The use of additional dye sensitizers gives a material which is sensitive also to yellow, orange, and red, thus providing photographic film which responds to the entire visible spectrum. These materials are designated as *panchromatic* and of this class Eastman Panchromatic Motion Picture Negative is a typical example. All of these materials in addition to their sensitivity to visible light are sensitive to those invisible radiations commonly referred to as the ultra-violet. By the use of certain sensitizing dyes the sensitivity can also be extended into the region of longer wave-lengths known as the infra-red. For a more complete discussion of this question of the color sensitivity of various types of photographic materials reference should be made to a paper by C. E. K. Mees.[1]

It is clearly impossible to hope to render in correct tonal relation a scene containing a wide variety of colors by the use of materials totally insensitive to some of these colors. Thus if a material of *ordinary* type is used red, orange, and yellow will be rendered as black; and green, which usually has a relatively high visual brilliance, will be rendered much darker than blue and blue-green which visually are relatively low in brightness. Some improvement is obtained by using an *orthochromatic* material since this renders green more nearly in its true position on the tone scale. It is only by the use of *panchromatic* material, however, that correct tonal rendition of all colors can be obtained.

It is usually desirable in motion picture work to reproduce as truly as possible the visual tonal values of the scene being photographed. Since practically all objects are colored to a greater or lesser degree it follows that the good reproduction of tone values can only be achieved by the use of panchromatic film. The rapidly increasing use of this material in motion picture work indicates that many workers are realizing its value. In the following pages the characteristics of this material will be discussed and attention called to some applications which are of particular importance.

A complete understanding of the principles involved in obtaining any desired reproduction of tone values by the photographic process requires a thorough knowledge of many factors, such as 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, the reflection characteristics of objects, etc. Before attempting to discuss the rendition of colored objects by photographic materials differing in color sensitivity it will be necessary to devote considerable attention to these fundamental principles underlying the photography of colored objects.

Radiation and Light

When a solid body such as a piece of carbon or a tungsten wire is raised to a high temperature it emits radiation which travels through surrounding space in the form of wave motion in the ether, a hypothetical medium supposed to pervade all space. This wave motion is of the transverse form and travels in a straight line at the enormous velocity of 186,000 miles per second. The frequency of vibration in this wave motion may vary enormously and since the velocity of propagation in any particular medium is independent of the frequency it follows that the length of the waves must vary inversely as the frequency. Thus *radiant energy* or *radiation* of high frequency has a shorter wave-length than that of low frequency, the *wave-length* being defined as the distance between two successive wave crests.

When radiation of certain wave-lengths falls upon the retina of the eye a sensation is produced which we call *light*. Thus radiant energy, a purely physical or objective phenomenon, when allowed to impinge on a sense organ, the retina, serves as a *stimulus* producing a subjective sensation or *response* which is designated in general as *light*. The nature of this sensation will be discussed briefly in a later section.

It may be well to point out at this time that the word *light* is commonly used in more than one sense. It is frequently used as designating the radiation itself and while such usage may be convenient it frequently leads to confusion. The usage of the word light in reference to radiation which does produce the sensation of light is to a certain extent allowable. Further extension of the usage in referring to radiation which does not produce a sensation of light is unfortunate and should be discouraged. Thus the terms ultra-violet light and infra-red light are objectionable. It is just as easy to speak of infra-red radiation and ultra-violet radiation and this usage is less likely to result in confusion.

Radiant energy being a purely physical or objective phenomenon can be measured and specified in physical units. A radiation consisting of a single wave-length (homogeneous radiation) can be completely defined by two terms, one referring to its quality (wave-length or frequency) and the other to its quantity (energy expressed in ergs). As stated previously the radiant energy emitted by a body at a high temperature contains wave trains of many different frequencies or wave-lengths. Such composite radiation may be analyzed into its component parts by use of a prism or diffraction grating. Thus if a beam of sunlight be passed through a prism and allowed to fall on a white surface, a band of light varying in color from one end to the other will be seen. This we call a spectrum and its formation depends on the fact that the prism refracts or bends the rays of different vibration frequencies by different amounts. If the dispersed radiation, instead of being examined visually, is examined by means of some sensitive receiving instrument (such as a thermopile) which responds to all radiation irrespective of its wave-length, the presence of radiant energy beyond the limits of the visible spectrum will be detected.

Having thus separated such composite radiation into its component parts the intensity and wave-length of each can be measured and in this way a complete and definite physical specification of the radiation obtained. The unit used to measure wave-length is the millimicron (mμ) which is equal to one one-millionth (0.000001) of a millimeter. The shortest wave-length which produces the sensation of light is 400 mμ, this giving rise to the color which we term violet. The longest wave-length which is visible is 700 mμ corresponding to the color which we call red. It should be understood that these limits of visibility are not sharply defined. They vary to a certain extent for different observers and depend very much upon the condition of the observer's eye and the intensity of the observed radiation. Radiation of wave-length shorter than 400 is referred to as ultra-violet, while that longer than 700 is termed infra-red. The diagram in Fig. 1 shows approximately the relation between wave-length of radiation and the color of the resulting sensation. As a matter of fact the complete physical spectrum extends into regions of much longer and shorter wave-length than shown in Fig. 1. But since in motion picture work certain limitations are set by the sensitivity of the eye and the photographic material and the absorbing characteristics of materials used (lens, objects photographed, etc.) it is not necessary in this discussion to consider radiation of wave-length shorter or longer than those included in the diagram.

From the physical standpoint the heterogeneous radiation emitted by various sources of light may be satisfactorily defined in terms of wave-length and the relative amount of energy emitted at each wave-length. Such data are usually expressed in graphic form by plotting energy as a function of wave-length. Curves thus obtained are called curves of spectral energy distribution. Data of this type for the light sources used extensively in motion picture work will be given in a later section.

Visual Sensitivity

The sensation produced when radiation falls upon the retina has three attributes: brilliance, hue, and saturation.

Brilliance is that attribute of any color in respect to which it may be classed as equivalent to some member of the series of grays ranging between black and white.

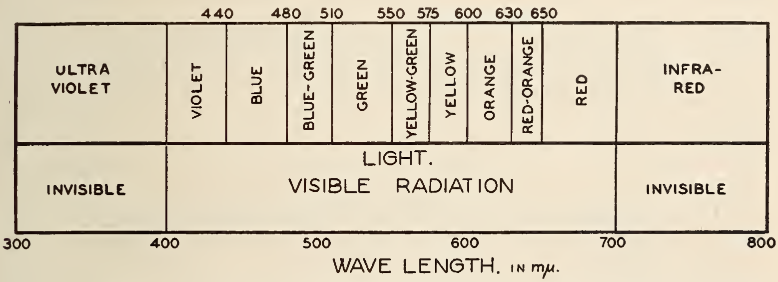


FIG. 1 Diagram showing approximate relationship between color and wave-length of radiation.

Hue is that attribute of certain colors in respect to which they differ characteristically from a gray of the same brilliance and which permits them to be classed as reddish, yellowish, greenish, or bluish, etc.

Saturation is that attribute of all colors possessing a hue which determines the degree of difference from a gray of the same brilliance.

An object in the visual field is visible by virtue of the contrast between it and its immediate surroundings or background. This contrast may be due to a difference in hue (hue contrast), to a difference in saturation (saturation contrast), or to a difference in brilliance (brilliance contrast). In the case of a photographic reproduction such as a print or image projected onto a screen, since all hue and consequently all saturation contrast is absent, visibility of object detail depends entirely on the existence of a brilliance contrast. It follows therefore that the reproduction of detail by the photographic process must be accomplished by reproducing as a *brilliance contrast* that contrast which in the object may be due either to a contrast of *hue, saturation,* or *brilliance.* This being the case the visual function, giving the relation between the wave-length of radiation and the brilliance of the resulting sensation, is of prime importance. This relationship is known as the visibility function and its form is obtained by measuring the magnitude of the brilliance attribute of the sensa-

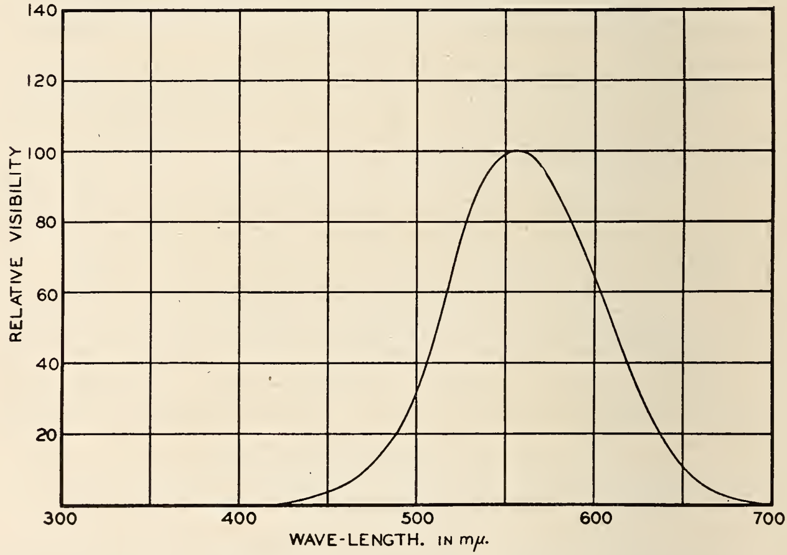


FIG. 2. Visibility curve for high brightness levels.

tion produced when the same radiation intensity of various wave-lengths acts upon the retina. In Fig. 2 this visibility curve is shown. This is obtained by plotting as ordinates the magnitude of the brilliance sensation produced by the action of *constant energy* intensity of wave-lengths as indicated along the bottom of the figure. It will be noted that the maximum effect (sensation) is produced by radiation of wave-length 556 mμ. The effect diminishes for shorter and longer wave-lengths so that at 430 mμ and 690 mμ the brilliance sensation for the same energy is only one per cent of that for wave-length 556 mμ.

The wave-length at which maximum visibility occurs and to some extent the shape of the curve depends vitally upon the energy intensity level used in its determination. The curve in Fig. 2 was obtained at intensity levels such as exist in well illuminated interiors and out-door daylight conditions. At lower intensities the maximum

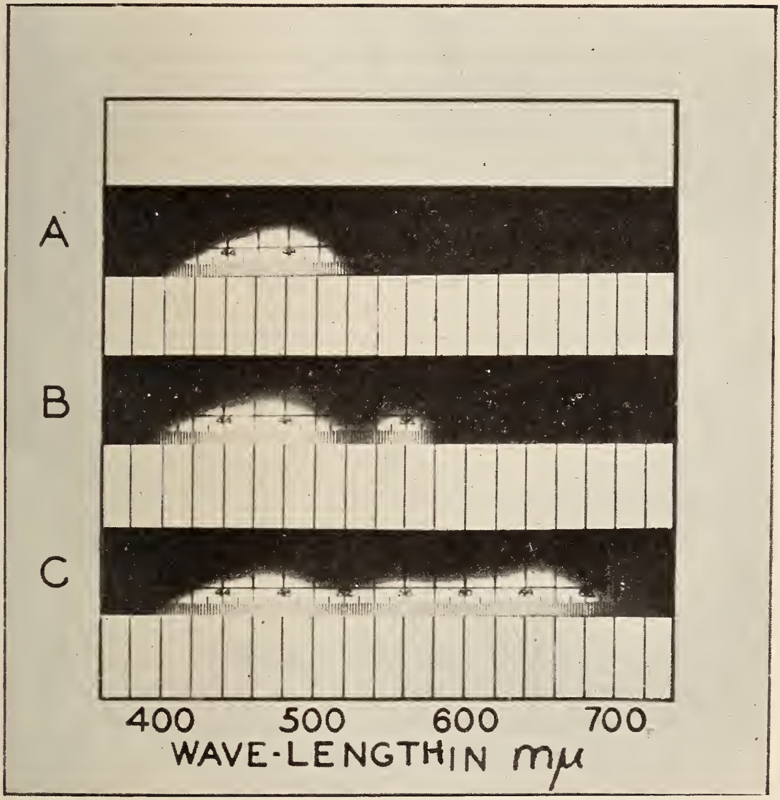


FIG. 3. Wedge spectrograms showing distribution of sensitivity for: *(A)* ordinary blue sensitive photographic material, *(B)* orthochromatic material, *(C)* panchromatic material.

of the curve shifts toward the shorter wave-lengths and if it is desired to apply such data to safe-light and dark-room illumination problems the curve as given in Fig. 2 is not applicable.

The visibility curve is of fundamental importance in all problems dealing with the reproduction of visual tone values by the photographic process. Used in conjunction with the data relating to the distribution of energy in the spectrum of the various light sources and curves showing the spectral distribution of light reflected from objects, it provides a means of computing or estimating the relative visual brightness of variously colored objects.

Photographic Sensitivity

As stated in the introduction, photographic materials vary enormously in their sensitivity to radiation of different wave-lengths. In Fig. 3 are reproduced three spectrograms which show qualitatively the spectral sensitivity for three typical classes of photographic materials. These spectrograms are obtained by use of a small spectrograph designed especially to test the color sensitivity of photographic materials. A diagram of this instrument is shown in Fig. 4. The light

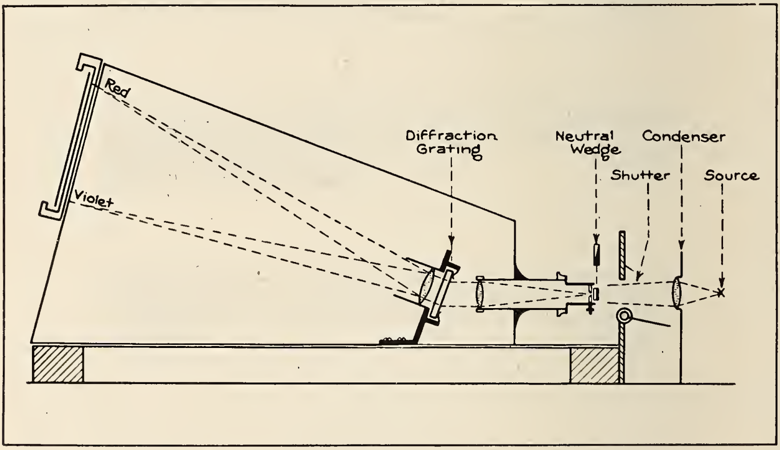


Fig. 4. Diagram showing the optical system of the wedge spectrograph.

source is imaged on the slit of the instrument by means of a condenser lens. The dispersing element is a diffraction grating, thus giving a normal spectrum, that is one in which equal wave-length intervals are represented by equal intervals on the photographic plate. The plate holder is provided with a ruled scale plate so that a scale of wave-lengths is automatically impressed upon a photographic plate when the exposure is made. A wedge of neutral gray glass is placed over the slit of the instrument so that the exposure, incident on the photographic materials being tested, decreases across the spectrum. In this way an indication of the variation in sensitivity throughout the spectrum is automatically obtained. The light source used is an unscreened acetylene flame. Since the amount of energy radiated by the acetylene flame at different wave-lengths is not constant but increases rapidly with increasing wave-length (see Fig. 8) it is evident that the curve obtained by outlining the light portion of these spectrograms is not the true spectral sensitivity curve for the material but the resultant obtained by compounding the spectral distribution of energy for the source with the spectral sensitivity of the photographic material. However since the same light source is used for all three materials they do show relative color sensitivity. It will be noted in case of the ordinary non-color sensitive material (A, Fig. 3) that the sensitivity becomes practically zero at 530 mμ. It follows therefore that any object reflecting radiation of wave-length longer than this value, no matter how bright it may appear visually, will be rendered as a very dark or black object by such materials. The band of green sensitivity conferred by the sensitizer used in making the orthochromatic material, (B, Fig. 3) has a maximum at 560 mμ and ends at approximately 580 mμ. It is evident therefore that this material since it responds to green light will reproduce green objects more nearly in their true position on the visual tone scale. In case of the panchromatic material (C, Fig. 3), however, the sensitivity extends beyond 700 mμ, the limit of the visible spectrum. This material is sensitive therefore to all wave-lengths of radiation which produce the visual sensation of light and it is only by the use of material such as this that a scene containing colored objects can be rendered in correct visual tone value.

The apparent decrease of sensitivity of all of these materials on the short wave-length side of 480 mμ is due to the selective absorption in the gray glass wedge used over the slit of the spectrograph. Actually this sensitivity does not decrease but rather increases in all cases, at least to 350 mμ. Since the glass used in making photographic objectives absorbs practically all radiation less than 350 mμ it is not important from the standpoint of motion picture work to know the wave-length sensitivity relation beyond this point.

While spectrograms such as are shown in Fig. 3 are useful in judging relative sensitivity they are not satisfactory for quantitative purposes. For such requirements a curve showing the relation between sensitivity, defined in some suitable terms, and wave-length of radiation is necessary. Unfortunately satisfactory data relative to materials used in motion picture work are not at present available. Work on these materials is in progress at present and it is hoped to be able to publish precise data of this nature in the near future. Some data, in the reliability of which we feel great confidence, relative to materials of very similar spectral sensitivity are, however, available and in Fig. 5 they are given in graphic form. The measurements were made with great care using a monochromatic sensitometer[2] especially designed for this purpose.

The sensitometric method of measuring the characteristics of the photographic material is illustrated by the curves shown in Fig. 6.

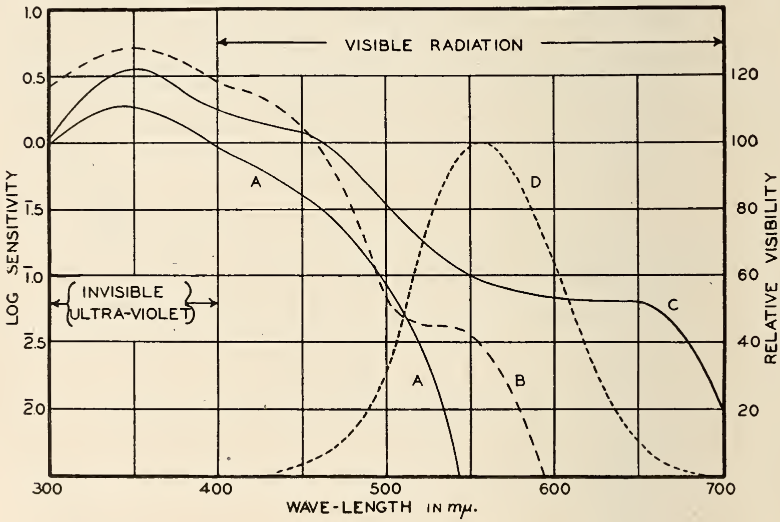


FIG. 5. Spectral distribution of sensitivity for photographic materials: *(A)* ordinary blue sensitive, *(B)* orthochromatic, *(C)* panchromatic. Curve D shows the visibility of radiation.

The samples of the material to be tested are exposed in a sensitometer, which is an instrument designed to impress on different areas of the material exposures of different magnitudes. It is customary to use a series of exposures increasing according to a logarithmic scale (1, 2, 4, 8, 16, etc.). Upon development this exposed strip yields a series of silver deposits, differing in density. The density, that is, the light absorbing power, of the various deposits are then determined by measuring the amount of light transmitted by them. If the intensity of the light incident upon such a deposit be represented by I_0 and the intensity of that transmitted by the deposit by I_1 then:

$$\begin{aligned} &\text{T (transmission)} = I_1/I_0 \\ &\text{O (Opacity)} = 1/T = I_0/I_1 \\ &\text{D (Density)} = \log O = \log 1/T. \end{aligned}$$

The characteristic curve of the material (illustrated by the curves in Fig. 6) is obtained by plotting density as ordinates against the logarithms of the corresponding exposures. If the series of exposures given in the sensitometer be of the logarithmic type then the logarithms of these numbers fall at equally spaced intervals on the X axis. A curve connecting the points thus established gives the relation between density and log exposure for the particular time of development used

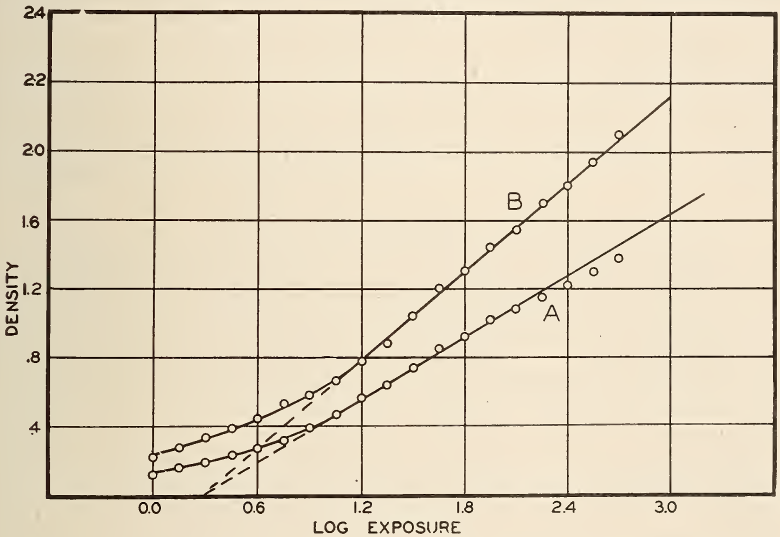


Fig. 6. Characteristic curves for Eastman Panchromatic Negative film.

in developing the test strip. The curves in Fig. 6 were obtained on Eastman Panchromatic Negative Film. Development was carried out in MQ 80 at a temperature of 20°C, curve *A* being developed for 4 minutes and curve *B* for 8 minutes. It will be noted that a large portion of these curves is represented to within the limits of experimental error by straight lines. The angle which the straight line makes with the log E axis depends upon the time of development as shown by the curves. It is evident that any given exposure may result in a density of variable magnitude depending upon the time of development. In specifying the sensitivity of the material it is not satisfactory therefore to express this in terms of a density produced by a given exposure without defining the extent to which development is carried. It is customary to specify the speed or sensitivity of a photographic material in terms of the exposure value at the point where the straight line portion of the curve extended cuts the log E axis. It has been found in the case of many photographic materials, when developed in solutions containing relatively small amounts of bromide, that this exposure value (which is termed the inertia) is independent of the extent of development. The inertia value therefore is in these cases independent of development and serves very satisfactorily as a means of specifying sensitivity. Since the value of inertia decreases as the speed of the material increases it is necessary to define sensitivity as the reciprocal of the inertia. In practical sensitometry it is desirable to specify the sensitivity of a material in terms of exposure expressed in visual units. The sensitometric exposures are therefore defined in terms of visual candle-meter-seconds of light of some definite reproducible spectral composition. The most suitable standard of light quality for sensitometric purposes is noon sunlight.

Due to the difficulties involved in measuring the brilliance factor of the sensation excited by the action of a monochromatic radiation on the retina, it is more satisfactory for the purposes of specifying the spectral sensitivity of a photographic material to express the exposure in terms of absolute energy units. In the monochromatic sensitometer referred to, the material under test is exposed to extremely narrow wave-length bands of radiation. By means of a suitable energy measuring device, such as the thermopile, the energy incident on the plate is determined. Exposure may be expressed therefore in terms of ergs per sq. cm. It has been found that the slope of the characteristic curves obtained with a fixed time of development depends upon the wave-length of the radiation to which the photographic material was exposed. Hence if the sensitivity for different wave-lengths of radiation be expressed in terms of the inertia, that is the exposure value at which the straight line extended cuts the log E axis, the result obtained is not a true indication of the relative density producing power of the different wave-lengths. In order to eliminate this objection it is necessary therefore to develop the strips exposed at various wave-lengths for different times so as to obtain characteristic curves of the same slope. If now the exposure be determined at which each wave-length gives a fixed density (such as $D = 1.0$) a satisfactory specification of spectral sensitivity is obtained. The sensitivity values as shown by the curves in Fig. 5 are defined in this manner, sensitivity being the reciprocal of the energy (expressed in ergs per unit area) which is required to produce a density of unity (D = 1.0) when the slope of the characteristic curves for the various wave-lengths is also unity.

Curve *A* is for Eastman 33 plates which is typical of the medium speed non-color-sensitive class of materials. Curve *C* is for Wratten and Wainwright panchromatic plates. A comparison of a wedge spectrogram made on this material with one made on panchromatic motion picture film indicated that the two are practically identical as regards color sensitivity. Very little error will be involved in assuming that curve *C* defines the color sensitivity of panchromatic motion picture film. Curve *B* is estimated by comparing a wedge spectrograph made on Par Speed motion picture negative film with one made on Eastman D. C. Ortho plate for which precise data are available. This curve may be subject to some error but it is probably sufficiently precise for all practical purposes.

Light Sources

The spectral composition of the radiation emitted by different light sources used in motion picture work varies enormously. These sources may for convenience be divided into two classes, (a) those having a continuous spectrum and (b) those having a discontinuous or line spectrum. Of the former the incandescent lamp is typical and of the latter the Cooper Hewitt mercury vapor lamp is a well-known example. As stated previously it is customary to show graphically the data relating to the spectral composition of radiation. These curves (spectral energy distribution curves) are obtained by plotting energy as a function of wave-length. Since in the discussion of the rendition of colored objects by means of photographic materials of different color sensitivity a knowledge of the spectral quality of the illuminating radiation is necessary, data relative to some of the sources commonly used in motion picture work will be given.

If a completely closed cavity be raised to a high temperature the spectral composition of the radiation emerging from this cavity through an aperture, which is small relative to the size of the cavity, follows a definite fundamental law and the spectral distribution of energy in this radiation can be computed precisely. Such a source is commonly referred to as a *black body* or a *complete radiator*. While this source is not of practical importance for illuminating purposes it serves as a very useful standard in terms of which to express the spectral composition of certain sources of practical importance. For instance it has been found that the color of light emitted by a heated tungsten filament is the same as that emitted by a black body at some definite temperature. The black body temperature at which the color match occurs is designated as the *color temperature* of the tungsten filament and it is quite customary to specify the quality of light emitted by a tungsten lamp and the efficiency at which this lamp is operating, in terms of its *color temperature.* The radiation from a

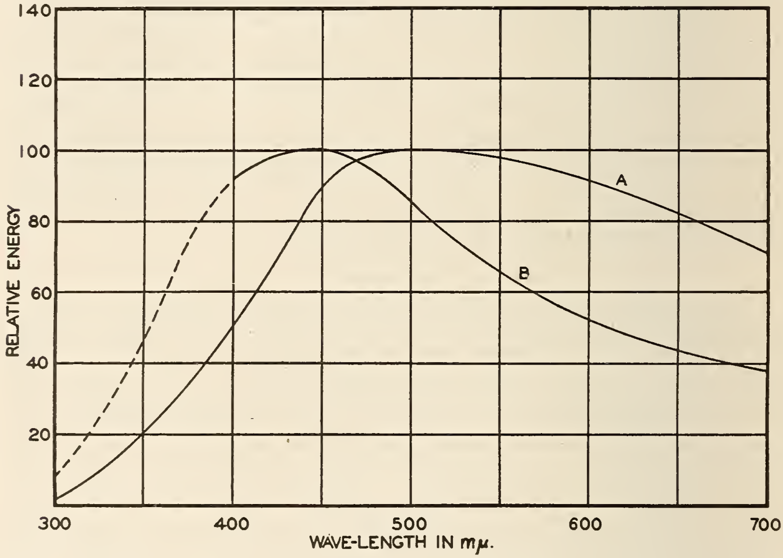


FIG. 7. Spectral distribution of energy in radiation from *(A)* noonday sun, *(B)* north sky.

black body at a temperature of 5400°K has been found to match in color that of noon sunlight. Hence the black body serves also as a useful standard for establishing precisely a definite standard of white. The spectrum of black body radiation is continuous and can be satisfactorily defined by a smooth curve the ordinates of which are energy and the abscissae wave-lengths. In describing the sources used in motion picture studios it frequently will be found convenient to describe qualitatively at least the composition of the emitted radiation in terms of its color temperature.

Sunlight. The spectrum of sunlight is of the continuous type crossed by many fine dark lines, Fraunhofer lines. These lines have little influence upon the distribution of energy in radiation from the sun and for all practical purposes the spectral distribution may be represented by a smooth curve, Curve *A*, Fig. 7; the maximum occurs at wave-length 510 mμ. The rapid decrease in energy between 400 and 300 mμ is due to absorption in the earth's atmosphere.

Skylight. Consists of radiation from the sun which has been scattered in various ways by the earth's atmosphere, air, dust, water vapor, etc. It is distinctly blue in color. The distribution of energy in light from a clear north sky is shown in Curve *B*, Fig. 7.

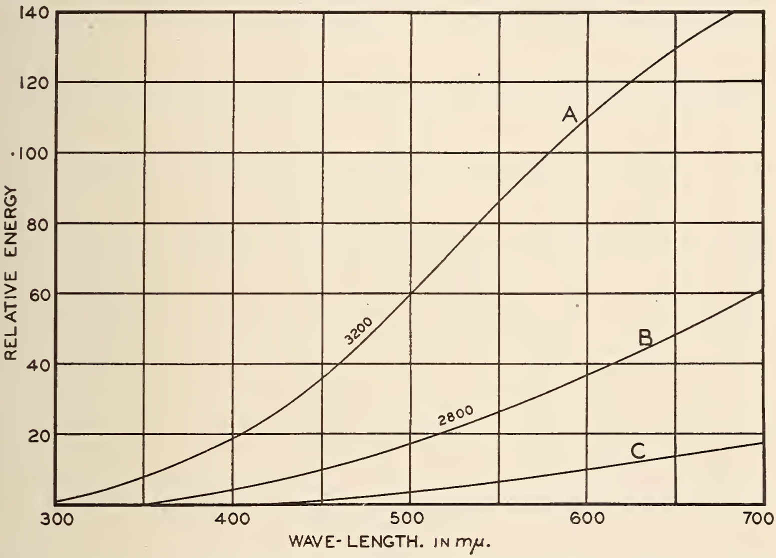


Fig. 8. Spectral distribution of energy in radiation from tungsten filament at various temperatures.

Incandescent Tungsten. While this source is used but little at present since it is relatively deficient in radiations of wave-lengths to which the Par and Super Speed motion picture negative film is most sensitive (350 to 550 mμ), it is probable that with the increasing use of panchromatic film it will become more widely used. The relatively large proportion of energy radiation in the region of longer wave-lengths (500 to 700 mμ) to which panchromatic film is sensitive makes it especially valuable for use with this material. In Fig. 8 are given three spectral energy distribution curves for tungsten. Curve *A* applies to the modern high efficiency high wattage gas filled lamps used in motion picture studios. Curve *B* is for a gas filled lamp operated at medium efficiency. Curve *C* shows the distribution of energy in the spectrum of a vacuum type lamp. These curves illustrate the way in which the energy radiated at any wave-length increases as the operating temperature is raised. Lamps of the type represented by curve *A* are now available in sizes from 1 to 30 KW. Of these the 3 and 10 KW units have proved most practical in motion picture studio work,[3] the 3 KW unit for general lighting and the 10 KW mounted in front of a parabolic reflector for spotting purposes. These lamps offer many advantages for studio use among which may

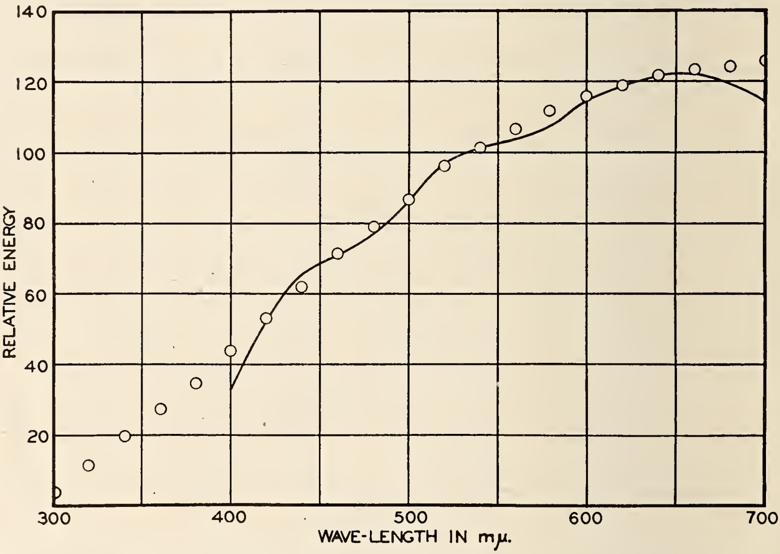


FIG. 9. Spectral distribution of energy in radiation from ordinary carbon arc. The small circles show the distribution of energy in the radiation from a black body at 4000°K.

be mentioned cleanliness, freedom from objectionable fumes, ease of manipulation, and the fact that when they have once been placed in position the attention of an operator is not needed. One man at the switch board can control all lamps on one or even several sets.

Carbon Arc—D.C., Hard Cored Carbons. The great preponderance of energy in the radiation from this source comes from the positive crater which is at a color temperature of approximately 4000°K. The spectral distribution of energy is of the continuous type and is practically identical with that of a black body at 4000°. The spectrum of the radiation from the arc stream is of the line or band type but the total energy due to this radiation is negligible in comparison with that from the crater. The distribution of energy is shown by the Curve in Fig. 9.

The High Intensity Arc—Sun Arcs. The carbons used consist of an extremely hard shell of carbon inside of which is a softer core impregnated with the fluorides of cerium and thorium. The spectrum of this source consists of a relatively low intensity continuous background due to radiation from the carbon walls on which is superposed a large number of bright lines due to the core material. These lines

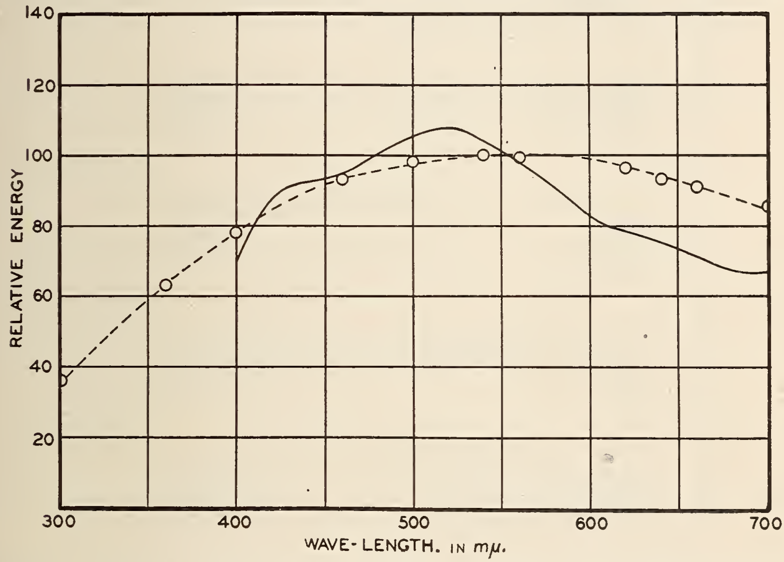


FIG. 10. Spectral distribution of energy in radiation from high intensity arc. The dotted curve applies to a black body at 5400°K.

are so numerous that for all practical purposes the spectrum is continuous. The color of the radiation emitted by the source as a whole matches fairly well that emitted by a black body at 5400°K. Noon sunlight also matches in color quite closely the radiation from a black body at this temperature. It will be seen therefore that the light emitted by this light source is very near to our standard of white. In Fig. 10 the solid curve shows the spectral distribution of energy emitted by the high intensity arc as determined by Benford.[4] The points designated by small circles show the distribution of energy in the radiation emitted by a black body at 5400° abs. It will be seen that the distribution of energy in the radiation from the arc is not identical with that from the black body at the temperature mentioned. The color match which exists is therefore only subjective.

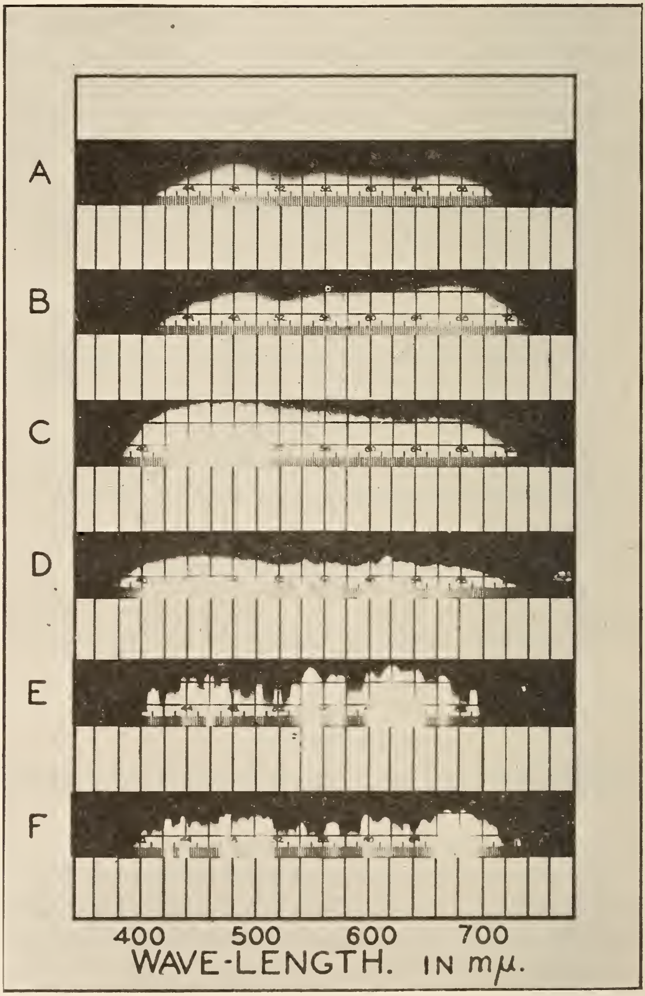


FIG. 11. Wedge Spectograms showing the relative distribution of energy in the radiation from various flame arcs: *(A)* sunlight, *(B)* acetylene flame, *(C)* white flame arc, *(D)* blue flame arc, *(E)* yellow flame arc, *(F)* red flame arc.

Flame Arcs. The carbons used in these arcs have cores which have been impregnated with various metallic salts. The spectrum consists of a large number of bright lines, due to the volatilization at high temperatures of these metallic salts, superposed on a continuous spectrum due to the incandescence of carbon. It is practically impossible to show the spectral distribution of energy by a curve on account of the presence of these numerous lines of variable width and intensity. Carbons of many different types are available on the market giving white, yellow, red and blue flame arcs. The white and yellow varieties are most commonly used in motion picture work. The spectrograms in Fig. 11 show qualitatively the distribution of energy in several different flame arcs.

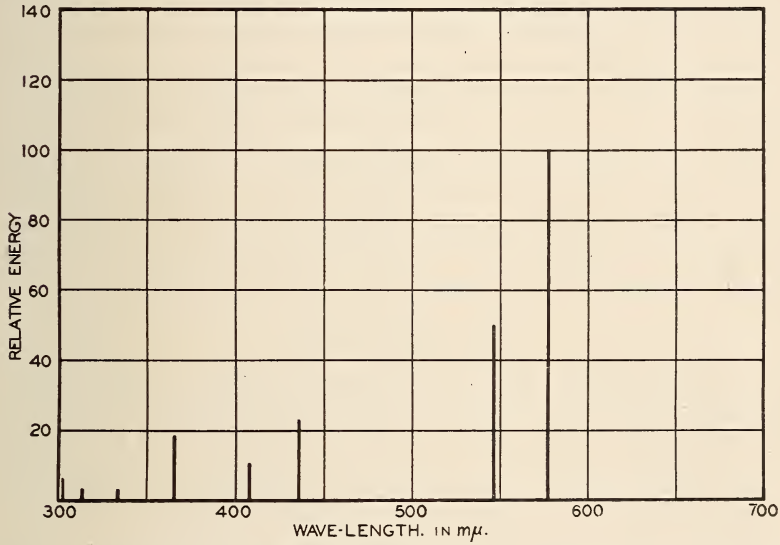


FIG. 12. Diagram showing the relative amount of energy radiated at different wave-lengths by the Cooper Hewitt mercury vapor lamp.

Mercury Vapor—Cooper Hewitt. The source of radiation is a column of mercury vapor enclosed in a glass tube. This vapor is excited by the passage through it of an electrical current which causes it to emit radiation at certain wave-lengths. Obviously such discontinuous radiation can not be represented by a continuous curve. The heavy vertical lines in Fig. 12 shows the wave-lengths at which emission occurs. The height of each line is proportional to the amount of energy radiated at those wave-lengths.

Mercury Vapor—Quartz Tube. In this source the mercury vapor is enclosed in a tube of fused quartz which due to its heat resisting properties permits the use of a higher operating temperature and gas pressure than can be used in case of the glass tube. This results in a marked enhancement in the amount of energy radiated at certain wave-lengths. Furthermore since quartz is very transparent to all wave-lengths down to 180 mμ (ordinary glass absorbs all radiation of wave-length shorter than 350 mμ) a large amount of ultra-violet radiation is emitted. While this radiation is very active photographically and the source is useful for certain photographic purposes it is of little value in the motion picture studio. Very few natural objects reflect ultra-violet radiation. Moreover the glass lens used in the camera does not transmit radiation of wave-length less than 350 mμ. It is possible of course to make lenses of quartz which do transmit this radiation but its use is of doubtful value since it would certainly produce a further departure from correct visual tone reproduction. It has been proved conclusively that radiation of wave-length shorter than 305 mμ is highly injurious to the eye. It is necessary therefore to enclose these quartz lamps in glass globes which absorb this injurious radiation. All things being considered, it does not appear that this source is suitable for studio use and so far as the authors know it is not used at present to any great extent.

The Nature of Color

As stated previously the sensation produced when radiant energy falls upon the retina has three fundamental attributes; brilliance, hue, and saturation. If, however, the relative proportions of the various wave lengths present in the stimulating radiation are properly adjusted the hue, and consequently the saturation, attributes are entirely absent. In such cases the sensation is described as *white* or *gray*, and can be expressed in terms of a single factor, its brilliance. Any radiation of such spectral composition as to give rise to a hueless sensation is spoken of as *white light*. While it is difficult to define precisely and absolutely a standard of white light it has been found experimentally that the radiation received at the earth's surface at noon on a clear day approximates closely the required spectral composition. For all practical purposes noon sunlight may therefore be adopted as a standard of white light.

Brilliance being an attribute of sensation can be expressed quantitatively only in terms of some sensation unit. The capacity of the stimulus, that is radiant energy, to produce the brilliance factor of sensation is denoted by its *luminous intensity* or *brightness*. These are physical quantities measurable by purely physical methods and expressible in definite physical units. In the case of reflecting surfaces brightness is the physical characteristic of interest in tone reproduction problems since it is the only factor which is reproducible by the photographic process. From the photographic standpoint therefore the perfection with which brightness distribution of the object photographed is reproduced in the print or screen image is a measure of the quality of reproduction.

The *gray* sensation differs from white only in the brilliance factor. The entire series of colors designated as grays (of which black and white are the limiting members) are due to spectral compositions of radiation capable of exciting hueless sensations. Any radiation differing in spectral composition from that required to produce a hueless sensation gives rise to a sensation which has a definite hue and which exhibits saturation in increasing magnitude as the difference between the spectral composition of the radiation and that of gray increases. Radiation of such wave-length as to excite sensation of which the hue is red, we speak of as red light, or it is called a green light if the hue be green, etc. Thus the hue or color is spoken of in common terminology as if it were an attribute of the radiation itself.

Non-luminous objects are visible by virtue of the radiation which they transmit or reflect. In case an object transmits or reflects all wave-lengths of visible radiations in equal proportions the spectral composition of the radiation which reaches the eye is precisely the same as that which illuminates the object. Such objects are said to be gray, black, or white depending upon the extent to which they reflect or absorb the incident radiation. The terms *non-selective* and *neutral* are also frequently used in referring to the reflecting or absorbing characteristics of such objects indicating that they absorb to equal extents all visible incident radiation regardless of wave-length. Objects which absorb some wave-lengths to a greater extent than others are referred to as *selective* absorbers. Radiation which has been reflected by such objects differs in spectral composition from that which was incident thereon. If the radiation incident on such an object is of such quality as to excite a hueless sensation (that is white) that which is reflected is so modified by *selective absorption* that it now excites a sensation having hue. Therefore we see an object possessing hue and consequently saturation. Hence we call it a colored object. Color in non-luminous objects is due therefore to *selective absorption*.

A gray object illuminated by colored light appears to be colored, while a colored object illuminated by colored light may appear either gray or of a different color. It is evident therefore that the color which an object appears to have at any time depends on two factors, its absorbing characteristics and the spectral composition of the light with which it is illuminated.

Keeping in mind now that the color which an object exhibits depends on its spectral absorbing characteristics, let us consider briefly the colors produced by various types of absorption. This subject is treated at length in the "Photography of Colored Objects" by C. E. K. Mees. To this reference should be made for complete information on the subject.

In Fig. 13 is shown a diagram in which the upper section represents the visible spectrum. This is divided into three equal portions representing approximately the three primary colors: red, green, and blue, the divisional points being indicated by the wave-length scale

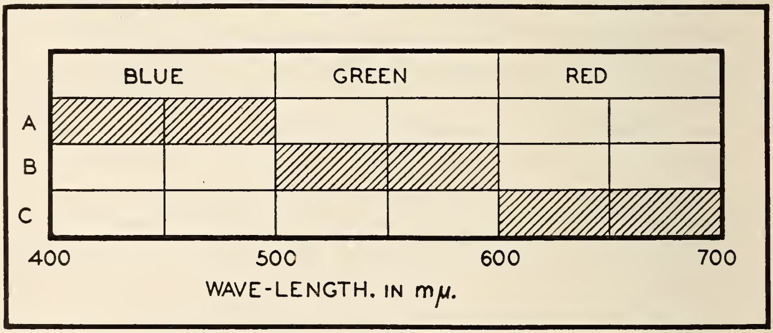


FIG. 13. Diagram illustrating selective absorption of narrow spectral bands.

at the bottom of the figure. It is assumed that this spectrum represents that of white light, for instance light from the noon-day sun. In the spectrum designated as *A* absorption of blue is indicated by the shaded area. The remaining light consists of red and green which added together give a yellow color. Thus the absorption of blue results in yellow. Complementary colors are defined as those which when added together result in white. It is evident therefore that blue and yellow are complementary to each other. Since the absorption of blue results in yellow the converse must be true that the absorption of yellow, that is the red and green components of white light, will result in blue. In the spectrum designated as *B* green has been absorbed. The remaining radiation consists of red and blue which when mixed together produce magenta. This brings to our attention for the first time a group of colors which are not present in the spectrum. They are commonly referred to as the purples and consist of mixtures, in various proportions, of red and blue. In the spectrum designated as *C* at the bottom of the diagram the shaded area indicates that red has been absorbed. The remaining light is blue-green in color and conversely it follows that if blue and green are absorbed the residual will be red. The absorption bands shown in Fig. 13 are relatively wide, each one including one-third of the visible spectrum. The colors produced by such absorption are of high saturation. Narrow absorption bands produce colors of lower saturation as illustrated in Fig. 14. In this figure a relatively narrow absorption band is indicated by the shaded area. This is moved into different positions in the spectrum, the residual color remaining after the absorption of the narrow band being indicated by the color names at the side of the diagram.

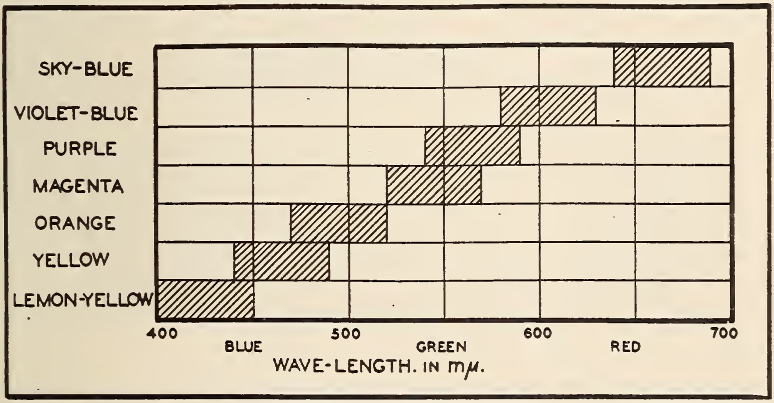


FIG. 14. Diagram illustrating selective absorption of narrow spectral bands.

All of the illustrations given thus far are based on the assumption that certain wave-lengths of radiation are absorbed completely as indicated by the vertical boundaries of the various absorption bands. This is only an ideal condition and is never encountered in the case of pigments and dyes with which we have to deal in practical work. The diagram in Fig. 15 illustrates the type of spectral absorption met with in the case of dyes and pigments. In *A* the narrow sharply defined area lying between wave-lengths 570 and 620 mμ represents a theoretical absorption band which produces a violet color. As a matter of fact violet can be produced in this way by inserting an opaque absorbing material in a spectrum formed by dispersion of white light.

Recombinations of the unabsorbed portions of the spectrum then result in light of violet color. Dyes and pigments, however, do not exhibit such sharp absorption characteristics. The shaded portion under the curve in diagram *A*, Fig. 15, represents the spectral absorption of a violet dye. It will be noted that it has a maximum absorption at approximately 600 mμ decreasing rather sharply on the long wave-length side to zero at approximately 700 and decreasing more gradually on the short wave-length side to zero at approximately 400 mμ. In diagram *B* the difference between a spectrum and pigment green is shown. The spectral absorption of the pigment green which is designated by the shaded area under the curve shows two maxima, one at the red end of the visible spectrum and the other at the violet

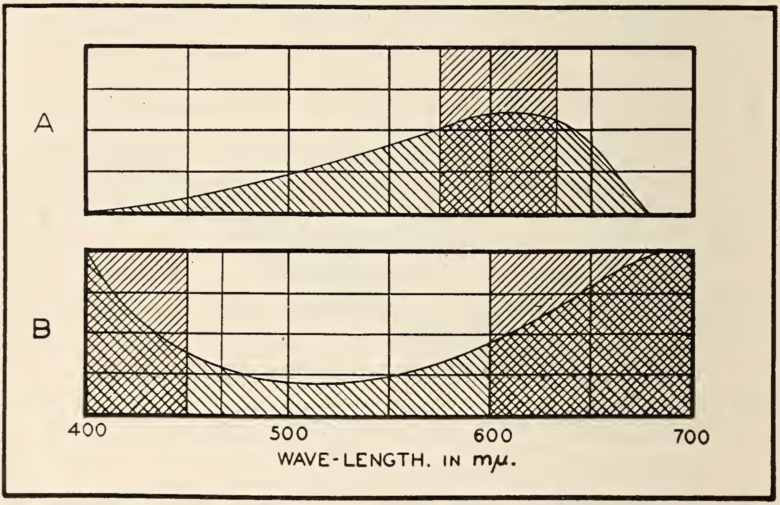


FIG. 15. Diagram illustrating the difference between theoretical and practical selective absorption.

with a minimum of absorption at approximately 550 mμ. Practically all pigment and dyes have absorption characteristics of the general type illustrated by the curves in Fig. 15, although in some cases the absorption may be somewhat sharper than shown. Quantitative data relative to the spectral absorption characteristics of colored materials are usually given in graphic form by plotting absorption or reflection as a function of wave-lengths. In Figs. 16 and 17 are given a group of curves showing the spectral reflection characteristics of a few typical pigments. These are taken from a publication by M. Luckiesh[5] who also gives a large amount of data relative to other colored materials such as dyes, inks, etc.

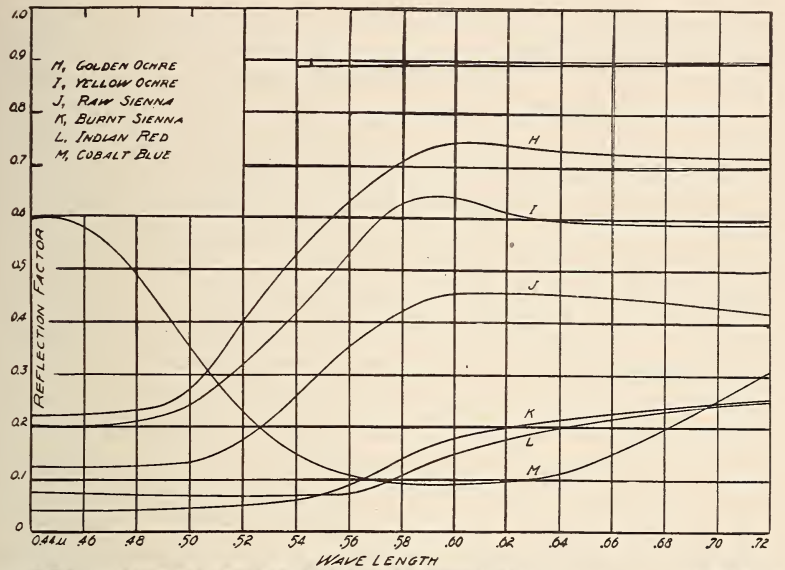


Fig. 16. Spectral reflection curves of various pigments.

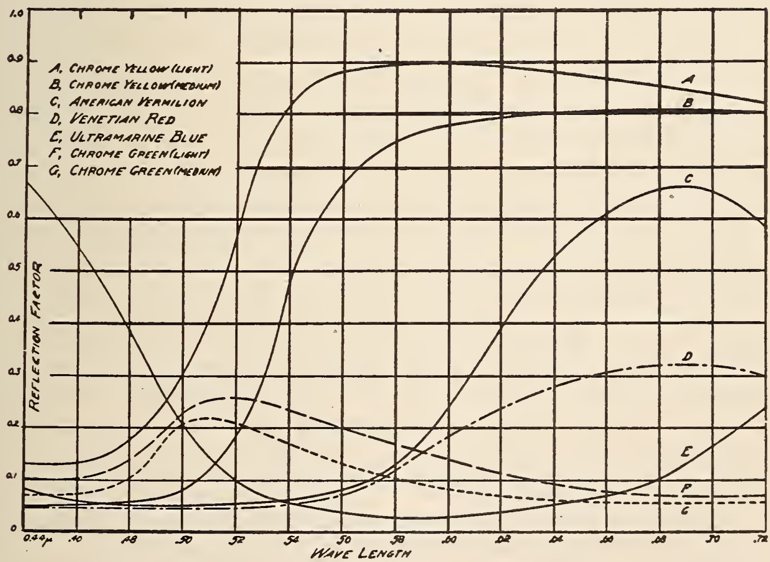


Fig. 17. Spectral reflection curves of various pigments.

An inspection of the curves in Figs. 16 and 17, reveals some facts of interest. The materials represented by these curves may be taken as representative in a general way of the coloring materials available for producing color in paints, fabrics, wall paper, etc. It will be noted that the curves for the red, orange, and yellow pigments have relatively very high reflection factors in the spectral region which they reflect most copiously. While the greens, blue-greens, and blues, even for those wave-lengths which they reflect to the greatest extent, have relatively low reflection factors. Even if the eye were of equal sensitivity to all wave-lengths of radiation red, orange, and yellow pigments would in general be much brighter visually than the greens, blue-greens, and violets. When it is remembered that the maximum of visibility lies at 556 mμ and that the visibility for longer and especially for shorter wave-lengths decreases very rapidly, it is evident that we should expect the reds and yellows to be colors of much greater brilliance in general than those in the shorter wave-length region of the spectrum. By multiplying the ordinates of the visibility curve by those of the spectral reflection curve for any given pigment a curve is obtained designated as the *luminosity* curve of the pigment. The area enclosed by this curve indicates the relative brightness of the pigment when illuminated by white light. Likewise the ordinates of the spectral sensitivity for the photographic material when multiplied by the ordinates of the spectral reflection curve give a curve known as the *photicity* curve. The area enclosed by this is proportional to what we may term the *photographic brightness* of the color considered. Applying this method of analysis to the various colored materials represented by the curves in the last two figures it is evident that colors of the green-blue-violet class will be relatively very bright as seen by a photographic material of ordinary type, while the colors of the red-orange-yellow group will have relatively low brightness. This relation being the reverse of the visual brightness of these colors explains the enormous distortion of tone values obtained when photographing colored objects on ordinary blue-sensitive film. If now we substitute panchromatic film it is apparent at once that the red-orange-yellow colors will be photographically relatively brighter than when rendered on ordinary film.

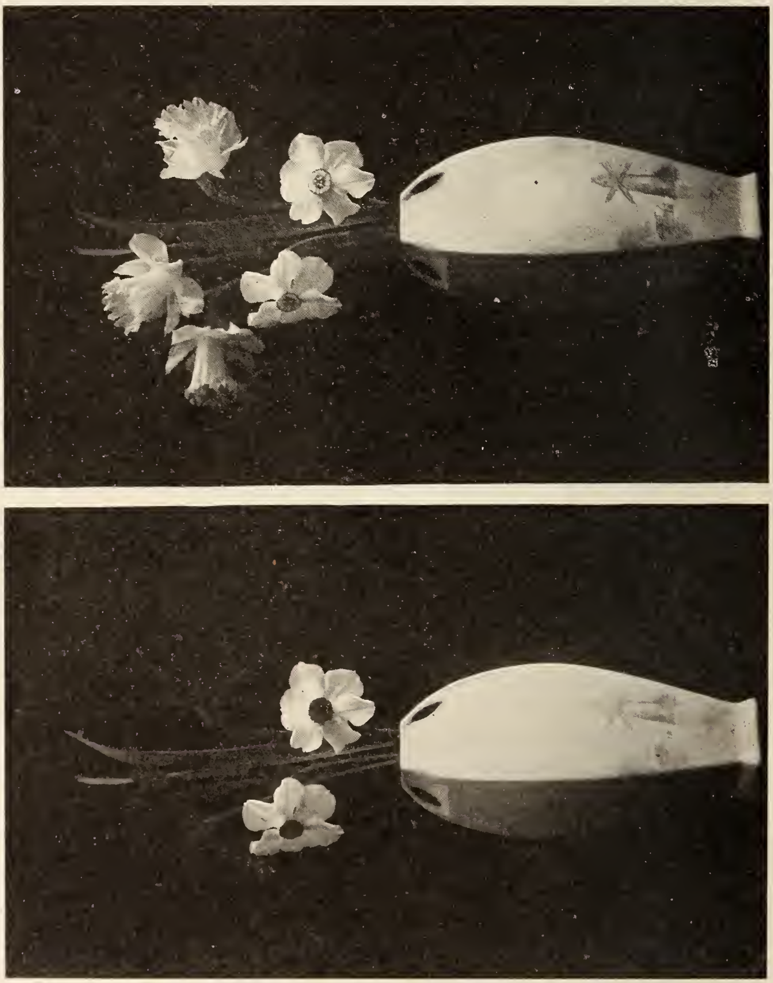
The spectral reflection characteristics of the colors which predominate in motion picture work has an important bearing on the effective or practical speed of the photographic film used. In measuring the speed of photographic materials by sensitometric methods it is customary to expose them to white light, in which approximately the same amount of energy is radiated at all wave-lengths. On this basis the speed of panchromatic motion picture negative is only slightly less than as that of Super Speed orthochromatic negative film. A careful study of the color of materials used in interiors including such things as wall papers, draperies, upholstering, furniture, wood trim, costumes, rugs, etc. shows that the so-called warm colors (those having a hue lying on the long wave-length side of 550 mμ) very greatly predominate, the cold colors (those having the hue lying on the short wave-length side of 550 mμ) being used in much smaller total quantity. Assuming that this preponderance of colors reflecting the longer wave-lengths exists, there is no doubt that the panchromatic motion picture negative is effectively appreciably faster than the orthochromatic.

Thus far very little has been said relating to colored objects of the transmitting type. These are of considerable importance since they provide a means whereby certain portions of the radiation reflected by the objects being photographed may be selectively absorbed. This may be accomplished of course by placing the colored glass or gelatine in front of the lens of the camera or between the light source and object illuminated. Colored glass in wide variety is available for use in the studio. This class of materials has been described at some length by Dr. Gage[6] in these Transactions, wedge spectrograms being given which show the selective absorption characteristics of a large number of samples. Colored filters made by incorporating dyes in gelatine are particularly adapted to photographic purposes. Due to the large number of dyes available a much greater range in types of selective absorption can be obtained in this way than it is possible to manufacture in the form of glass. A very complete line of filters of this type are commercially available and are described in detail in "Wratten Light Filters." In this booklet spectral absorption curves are given for approximately one hundred different absorbing filters suitable for use in various fields of photographic work.

To deal completely with the subject of using light filters with panchromatic film under all possible conditions of light source, object, and desired result would in itself constitute a lengthy discussion. This subject has been treated exhaustively in the book mentioned previously, "The Photography of Colored Objects" and for further information the reader is referred thereto.

Rendition of Colored Objects by Orthochromatic and Panchromatic Film

From a consideration of the spectral sensitivity of orthochromatic and panchromatic film, the spectral reflection curves of various colored objects, and the distribution of energy in the radiation emitted



FIGS. 18, 19, 20. Photographs illustrating the difference in rendition of colors by orthochromatic and panchromatic materials.

by light sources, it is evident that a marked difference in the photographic rendition of variously colored objects should be obtained. A few actual examples of such differences will now be given. In Fig. 18

are reproduced two photographs of a white vase on which is a design in blue. The flowers are two varieties of narcissus, the upper ones being bright yellow and the lower having white outer petals with a yellow central cup. The reproduction on the orthochromatic plate renders the yellow as very dark, only slightly lighter than the black background. The superior rendition of visual brightness is obvious in the reproduction on the panchromatic material, the yellow being rendered almost as bright as the white thus corresponding to the visual impression. In Fig. 19 are shown two reproductions of a poster.

Fig. 19.

The sky in the original is dark blue, while the moon is represented by a bright orange disc. It will be noted that the orthochromatic material renders the moon as much darker than the sky background this being the inverse of the visual relationship. On panchromatic film the brightness ratio between sky and moon is reversed and corresponds with the visual ratio. In Fig. 20 is shown a photograph of a painting. The dress is a brilliant scarlet while the background is very dark. The orthochromatic material reproduces this so that the scarlet dress, which is visually many times brighter than the black background, is just perceptibly lighter than the background. In case of the reproduction on panchromatic material the brightness ratio is as it should be, the scarlet dress being rendered as an area of much higher brightness than the black background. Illustrations of the improvement in

Fig. 20.

tone reproduction by use of panchromatic material could be multiplied indefinitely. These three, however, serve as sufficient illustration.

Uses of Panchromatic Film

The application of panchromatic motion picture film to practical problems may for convenience be classified in two main divisions:

(a) to obtain correct reproduction of the visual brightnesses in a scene containing variously colored objects and (b) to obtain some desired distortion of the brightnesses in a scene consisting of variously colored objects.

Correct Reproduction

The first of these purposes may be referred to as the *normal* usage of such film. The curves showing the relation between sensitivity and wave-length for this material indicate that it is sensitive to all wave-lengths of visible radiation. There is, however, an appreciable preponderance of sensitivity to radiations of shorter wave-length. The required spectral distribution of sensitivity in a photographic material in order to obtain *under all conditions* precise reproduction of visual brightness is that the curve of spectral sensitivity of the material shall be identical in shape with that of the visibility curve of the eye. A comparison of the visibility curve with that of spectral sensitivity of panchromatic film shows that there is still an appreciable discrepancy. By placing over the lens a filter which absorbs radiation selectively it is possible to modify the *effective spectral sensitivity* of the photographic material. Thus by using a yellow filter which absorbs radiation of shorter wave-lengths the *effective* sensitivity of the film at those wave-lengths can be reduced. If the spectral absorption characteristics of this filter is properly adjusted to that of the photographic material the spectral sensitivity can be made for all practical purposes identical with the visibility function of the eye. It is obvious that the absorbing characteristics of the filter which is used for this purpose will depend directly upon the spectral distribution of energy in the radiation of the light source used for illuminating the object. When panchromatic motion picture negative is used outdoors, the object being illuminated by sun and sky light, it is necessary to use a yellow filter such as the W & W No. 8 (K-2) in order to obtain correct reproduction of visual tone values. When this material is used in the studio with such sources as the high intensity arc, sun arc, or white flame arc, the same filter is approximately correct. A set illuminated by light from the ordinary hard cored carbon arc, operating at a color temperature of approximately 4000°, requires a slightly lighter yellow, filter K-1 $\frac{1}{2}$ being approximately correct. If high efficiency tungsten lamps are used no filter is required. The relatively small quantity of short wave radiation and the relatively large quantity of long wave radiation compensates approximately for the excess of blue and violet sensitivity.

The use of a photographic material which will give correct reproduction of visual brightness values has many advantages. Under such conditions the distribution of the tone values (brightness) in the set is seen by the scenic artist, camera man, director, and the actors themselves just as it will be reproduced on the screen. There is little doubt that this is of great value since it enables those responsible for the composition of the picture to judge more precisely when the various elements of light and shade bear the proper relation to each other. Flesh tones and quality are rendered as seen by the eye. Problems of make-up very largely vanish when panchromatic film is used. It is only necessary to instruct the actors to make up as they wish to be seen. There seems to be little doubt that this simplification of the make-up problem is of considerable value. Both camera man and director should be able to detect any faulty or objectionable make-up much more readily than under conditions which exist at present where the make-up must necessarily be incorrect visually in order to produce a pleasing result on the screen. The rendition of flesh color by the non-color sensitive material is notoriously bad. Normal skin being a tissue filled more or less with blood vessels has a yellow or red dominant hue which an orthochromatic film at present used necessarily renders much darker on the tone scale than it appears visually. Lips in particular render as almost black. The sensitivity of the panchromatic material to the wave-lengths of radiation reflected by flesh entirely eliminates this trouble. Skin imperfections such as freckles, enlarged blood vessels, etc. are practically invisible when panchromatic film is used. The rendition of various types of hair on panchromatic film is much more satisfactory. For instance auburn hair which visually is of high brightness is rendered on ordinary film as very dark. On panchromatic film this assumes its true position on the visual tone scale. Yellow hair also renders much too dark on orthochromatic film but on panchromatic is correctly reproduced.

The predominance of *warm* colors in studio work has already been mentioned. At first thought it may seem almost impossible to make any general statements relative to what colors are used predominantly in motion picture sets. It should be remembered, however, that the sets created in the studio merely imitate the homes and surroundings of everyday life. A careful consideration of the subject indicates that the vast majority of the walls, draperies, and objects with which we surround ourselves are characterized by the warm colors. This fact tends to make the effective speed of panchromatic film much greater than that indicated by the values based upon white light measurements. There is little doubt that if panchromatic film is adopted for studio use, illumination levels much lower than are at present used will be adequate for obtaining satisfactorily exposed negatives. The preponderance of red, orange, yellow, yellow-green, and green and their related shades and tints in studio work and the relatively high sensitivity of panchromatic film to the red end of the spectrum are very favorable toward the use of high efficiency tungsten lamps for studio illumination. As mentioned before these sources have many virtues to recommend them. A studio set lighted by tungsten should produce an atmosphere differing less from real life surroundings. It seems reasonable to suppose that the dramatic artists should respond to this condition and be better able to portray their roles with realism.

Attempts have been made in the construction and decoration of studio sets to use only black, white, and grays. Certainly when using non-color sensitive film this offers advantages in enabling the artist, camera man, and director to determine with certainty the composition of the picture in light and shade as it will appear on the screen. No objection to such procedure exists from the standpoint of the audience since they have no means of detecting the absence of color in the sets. Our information is that these attempts were failures because the actors in these sets were so affected by the unnaturalness in the surroundings, due to the absence of color, that they could not do good work. This seems to be good evidence in the support of the contention that naturalness and semblance to reality in studio sets is at least helpful to satisfactory dramatic performance.

In the making of many high class pictures every effort is made, frequently at great expense, to duplicate to the last detail the quality and color of the scene to be represented. Perhaps the action takes place in the drawing room in a home of wealth and luxury. The walls are decorated in a carefully balanced color scheme, the window openings are treated with rich fabrics of harmonizing colors, oriental rugs are strewn over the floor and the ladies appear gowned in the latest creations, symphonies in color. Now comes a jarring note; the faces and arms must be plastered with a putty colored powder and the set flooded with a light which is harsh and glaring or of a quality such as to impart an extraordinary ghastliness to the scene. The use of panchromatic negative film will help to eliminate some of these objectionable conditions. Make-up can be just the same as would be worn in real life under similar conditions and the set may be satisfactorily illuminated by using light of the same general quality as would be found in such an interior.

After having spent a great deal of thought and money in the construction and embellishment of the set in colors duplicating the original, the scene is photographed on material which is totally blind to one-half of the visible spectrum, and that half the one that includes the colors which predominate in the average interior. It is not an infrequent experience to find that the carefully balanced color scheme is rendered on the screen in such a way as to destroy completely the black and white compositions desired. The use of panchromatic film will eliminate such unfortunate occurrences.

Distorted Reproduction

It may be necessary at times to photograph a scene in which two or more adjacent elements are of different hues and saturations but identical in visual brightness. To the eye such details are visible by virtue of the *hue* or *saturation* contrast. If panchromatic film corrected by a filter designed to give correct reproduction of visual brightness is used such objects will not be differentiated in the negative record. To obtain the desired differentiation it is necessary to disturb the adjustment either by using a filter of different color or by changing the quality of the illumination. In this way distorted rendition of the visual brightness values is obtained. As an illustration of such a case consider a bright green card on which is printed a design in red. It is quite possible to adjust the two colors so that no brightness difference exists between the two colors. Photographed on panchromatic film with a filter adjusted to give correct tone values the design is invisible. Now suppose a green filter is placed over the lens. No red light is transmitted and hence the design in red is rendered in black or very dark against a light background. Or suppose a red filter is used instead of the green. The light reflected by the background (green card) is now absorbed and the design is rendered as light on a dark ground. Thus the distortion in either direction may be obtained. The operator must decide which color should be rendered as lighter than the other. This decision will depend very much upon the circumstances but in general it is best to use a filter which will render a *warm* color (one included in the red, orange, yellow, yellow-green series) as lighter than one of the *cold* group. This follows from the fact that colors belonging to the long wave-length end of the spectrum are usually brighter than those of short wave-length. Moreover it is not advisable in general to use a filter which completely absorbs one of the two colors since the great contrast thus obtained in the reproduction is much greater than the visual contrast due to the hue difference between the two colors. The general principle to be remembered is to use a filter which absorbs one of the colors to a *greater* extent than the other.

Haze Elimination. In making pictures outdoors it is sometimes desirable to obtain rendition of distant details which are partially or entirely obscured by atmospheric haze. Such haze is due to the scattering of light by dust particles or water vapor suspended in the air. In most cases haze is not white but more or less blue in color. By using panchromatic film with a filter which absorbs blue selectively

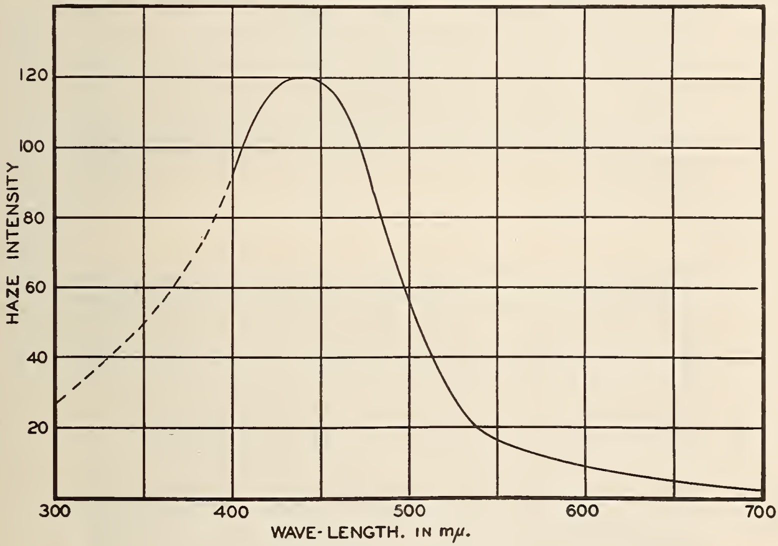


Fig. 21. Spectral distribution of radiation in atmosphere haze.

the non-image-forming haze light can be absorbed to a great extent while the minus-blue (that is yellow) light from the distant parts of the scene are transmitted and give satisfactory photographic records. In Fig. 21 the curve shows the spectral distribution of energy in haze light. It will be noted that there is a very great predominance at wave-length 440 mμ. The distribution on the short wave-length side of 400 has not been determined experimentally. The dotted part of the curve is an estimated extension. As shown by the curve the amount of energy in the haze light in the longer wave-length region is much less than in the blue.

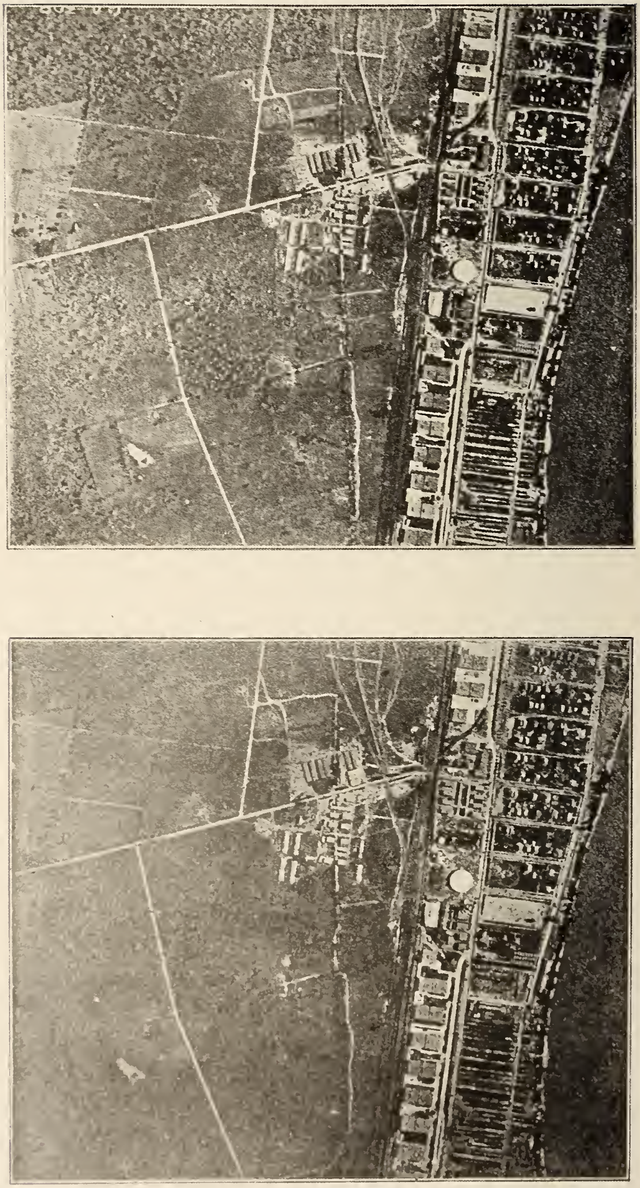


FIG. 22. Aerial photographs illustrating the elimination of haze by use of yellow filter with panchromatic film.

The filter required for this work depends upon the haze density and the distance of the most remote object which it is desired to record. Ordinarily a Wratten No. 8 (K2) or Wratten No. 12 (minus-blue) will give good results. The picture at the right in Fig. 22 illustrates the elimination of haze by use of panchromatic film with a No. 12 filter. The left hand picture in this figure was made on an ordinary non-color sensitive plate without a filter. It will be noted in this case

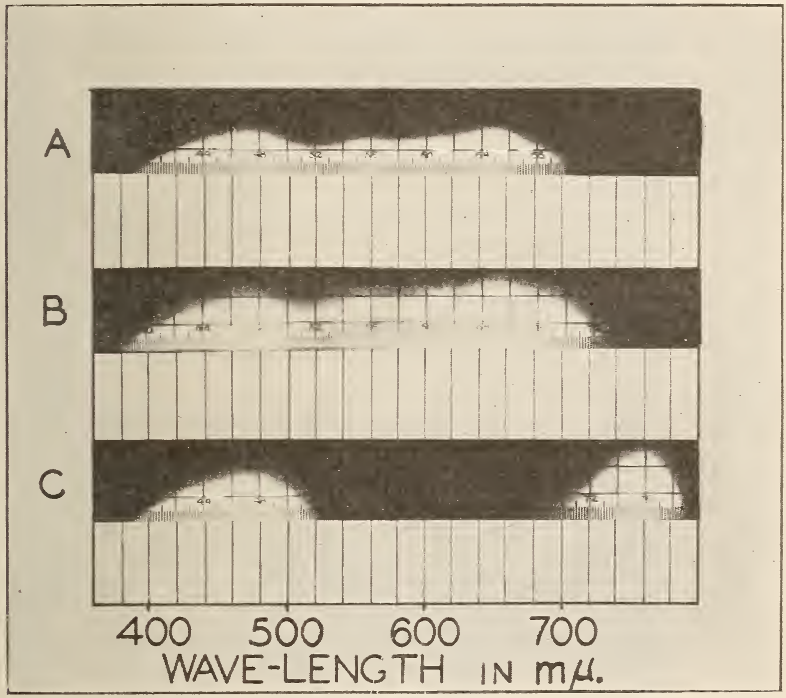


FIG. 23. Wedge spectrograms showing the spectral sensitivity of: *(A)* Eastman Panchromatic Negative film, *(B)* Hypersensitized Panchromatic film, *(C)* Panchromatic K.

that a large part of the detail on the ground is obscured by the haze while in the case of the one taken with the filter, this detail is clearly rendered.

In the case of very dense haze or extreme distance it may be necessary to use a red filter, Wratten No. 25 or Wratten No. 29. A film more sensitive to red light than the standard panchromatic motion picture negative is required in such cases and hypersensitized

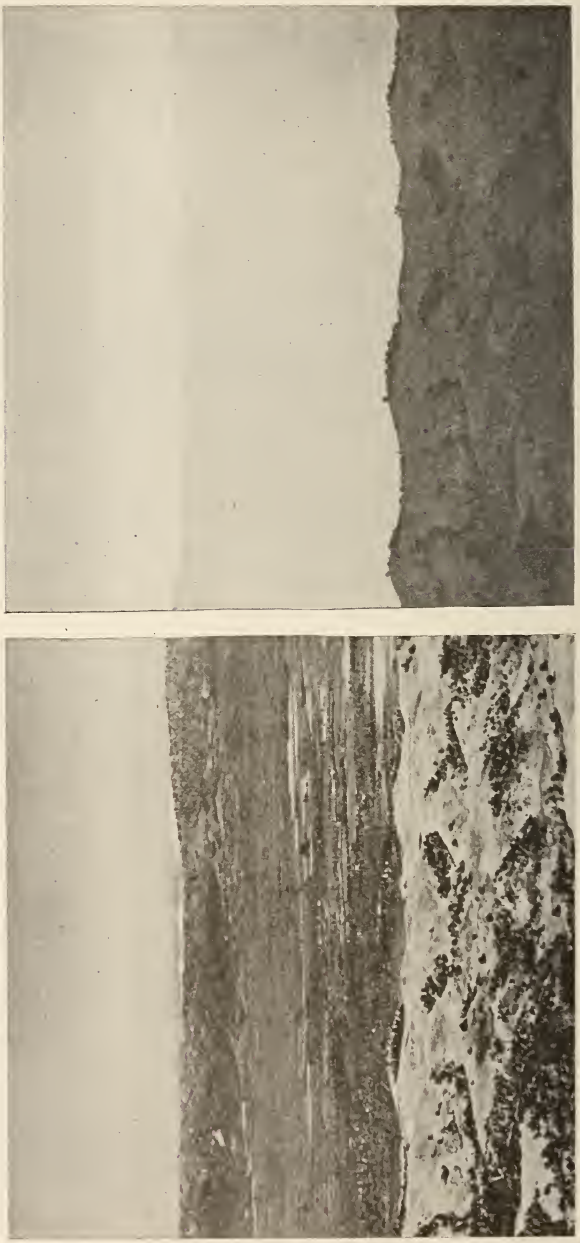


FIG. 24. Photographs showing the elimination of haze by the use of Eastman Panchromatic K film with red filter.

panchromatic film must be used. Standard panchromatic negative film may be hypersensitized by treating with ammonia. The film is bathed 1.5 minutes in 4 per cent ammonia at 50°F and dried as rapidly as possible. Hypersensitized film does not keep for a very long time but can be relied upon for a week or more. The general sensitivity of the film is increased appreciably by this treatment but the green and especially the red sensitivity is increased in much greater proportion than the blue. The red sensitivity of film hypersensitized in this manner is about four times as great as the standard product. A spectrogram showing quanlitatively the spectral sensitivity of hypersensitized panchromatic film is shown at *B* in Fig. 23. Even greater haze cutting can be obtained by using Eastman Panchromatic K film which is very sensitive to infra-red radiation (see Fig. 23, *C*) and not at all sensitive to the green, yellow, and orange of the visible spectrum. Any filter which completely absorbs the short wave-lengths to which the film is sensitive (wave-lengths less than 500 mμ) is satisfactory for use with the film. The photographs shown in Fig. 24 illustrate the haze elimination obtained by use of Panchromatic K film.

Moonlight Effects. Some years ago, Prof. R. W. Wood of Johns Hopkins University called attention to the fact that landscapes when photographed by infra-red light present very peculiar and weird appearances. This is due to the fact that the light from the sky contains no infra-red radiation and hence the sky is rendered as totally black, while green foliage is rendered as white. This follows as a consequence of the peculiar spectral reflecting characteristics of green leaves containing the coloring matter known as chlorophyll. Chlorophyll reflects quite strongly the extreme red and infra-red radiation. Hence in a photograph taken by infra-red radiation green leaves are rendered as white. In a paper published in No. 22 of these Transactions (p. 20) Mr. J. A. Ball suggested the use of film sensitized with Kryptocyanine for obtaining moonlight and night effects without the aid of artificial light. Film of this type is now commercially available under the name of Eastman Panchromatic K. In Fig. 23 at *C* the spectrogram given shows qualitatively the spectral sensitivity of this material. It will be noted that in addition to the usual sensitivity of ordinary film in the blue region it shows a band of high sensitivity having a maximum at wave-length 760 mμ. This being in the infra-red region the eye is entirely insensitive to radiation of this wave-length. Panchromatic K film, as shown by the spectrogram, is insensitive to the green, yellow, and orange of the visible spectrum.

In using this material for obtaining pictures by infra-red light it is only necessary to use a deep yellow or orange filter which absorbs completely the light of short wave-length to which the film is sensitive.

Effects which suggest night scenes can be made by using hypersensitized panchromatic film with a deep red filter such as Wratten No. 25 or No. 29. The result is much more striking, however, and approaches the true night or moonlight effect when Panchromatic K film is used with a red filter such as No. 25. The sensitivity of this material to the infra-red radiation is such that under bright sunlight conditions outdoor motion pictures at standard speed can be made

FIG. 25. Photograph of landscape made in full sunlight on Panchromatic K film with infra-red filter.

with a lens having an aperture of f. 3.5. This applies to the most favorable conditions. In case the sunlight is not of highest intensity it may be necessary to use a lens working at f.1.9. In Fig. 25 is shown the reproduction of a photograph made on Panchromatic K film.

Development of Panchromatic Film

Dark Room Illumination

Since panchromatic film is almost equally sensitive to all colors, including red, the film would be fogged if handled in the dark room with the ordinary safe-lights. With a Wratten Series No. 2 (red) 8×10 safe-light containing a 25 watt bulb, if film is exposed 12 inches away from this safe-light for 10 seconds a fog density of 1.5 is obtained with normal development, which density is in excess of the average highlight density of a negative. With Super Speed motion picture film under the same conditions after exposing for 2 minutes only a just visible fog is produced.

In selecting safe-lights for panchromatic film they should be such that they transmit light to which the eye is most sensitive. For low light intensities the eye is most sensitive to light having a wavelength around 520 mμ. The Wratten safe-lights Series Nos. 3 and 4 transmit light in this region of the spectrum, but panchromatic film will be fogged by such light if the intensity and time of exposure exceed a certain critical value. For equal visibilities the light transmitted by the Series 3 safe-light has only 1/60 of the photographic effect of the Series 2 safe-light.

The problem, therefore, of illuminating the dark room is to utilize a minimum quantity of the light transmitted by the Series 3 Wratten safelight to the best advantage.

General Illumination

For each 100 square feet of ceiling area one 8×10 inverted safe-light fitted with a 25-watt bulb and Series 3 filter adjusted 2 feet from the ceiling is satisfactory. The walls of the dark room should be painted white or light green so as to reflect as much light as possible and all conspicuous objects should be painted a light color so that they will be more readily visible. In a dark room illuminated in this manner from 10 to 15 minutes are required before the eye accommodates itself to this low intensity level; the time for accommodation depending upon the previous intensity to which the eye was subjected.

With such illumination a rack of film placed anywhere on the dark room floor will not become fogged in less than 25 minutes so that in most cases it is possible to double the wattage and therefore the brightness of the lamp in the safe-light when there will still be ample margin of safety. If it is desired to double or triple the brightness of the safe-lights it is advisable to partition off a portion of the dark room for loading so that the film racks will be exposed as little as possible to the stronger illumination in the dark room.

Film Inspection Lights

With the rack system of development it is customary to examine the film at intervals by means of a safe-light illuminator extending across the developing tank. If the illuminator is fitted with a Series 3 safe-light and the intensity adjusted either by inserting tissue paper, opal glass, or ground glass between the lamp and the safe-light so that the film is not fogged in less than 10 seconds at a distance of 12 inches, this will provide ample time for inspection while the visibility will be satisfactory. The lamps in question should be fitted with a foot switch so that the lamp is lighted only while inspecting the film.

A simpler method of illuminating the film for inspection is by means of a pocket flash lamp fitted with a Series 3 safe-light about 2 inches square. The intensity should be adjusted so that the film is not appreciably fogged in less than 5 seconds at a distance of 3 inches. This method of inspection has the advantage that if any fog is produced it is only local, and its use eliminates fire hazard.

Use of Desensitizers

Desensitizers have the remarkable property of more or less destroying the light sensitiveness of the unexposed portions of an exposed image while they do not interfere with the progress of development of the exposed portions. Therefore, by bathing the exposed film previous to development in a solution of the desensitizer or by incorporating the desensitizer in the developer, after development has proceeded for one or two minutes the film can be freely examined in a light of such intensity that it would otherwise be fogged.[7] The most satisfactory desensitizer known is Pinakryptol Green, obtainable from H. A. Metz, 122 Hudson St., New York, N.Y. For use as a preliminary bath dissolve 6 grains of Pinakryptol Green in each gallon of water (0.1 grams per liter) and immerse the film for 2 to 3 minutes before transferring to the developer. When used in the developer dissolve 2 1/2 grains per gallon of developer (0.04 grams per liter). With some developers rich in hydroquinone it is impossible to add the desensitizer directly to the bath because it is precipitated.

After such treatment with a desensitizer, panchromatic film may be inspected with safety with a Series 4 Wratten safe-light containing a 25-watt bulb at a distance of 12 inches. This gives ample illumination under all circumstances. When using desensitizers and correspondingly brighter dark room illumination there is always danger of accidentally fogging an emulsion in the brighter light before the desensitizing solutions have had sufficient time to act. It is preferable to give a preliminary bath in the desensitizer in a separate room and then transfer the racks to the dark room rather than to add the desensitizer to the developer.

Processing Solutions

Any developer formula which is satisfactory for Super Speed or Par Speed negative film is suitable also for panchromatic film. The

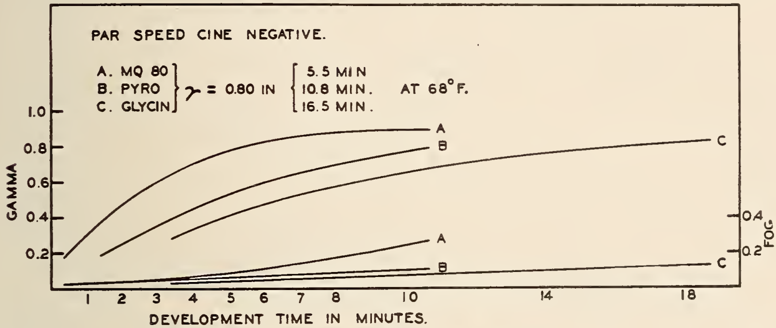


FIG. 26. Time-gamma curves in different developers with motion picture Par Speed negative film.

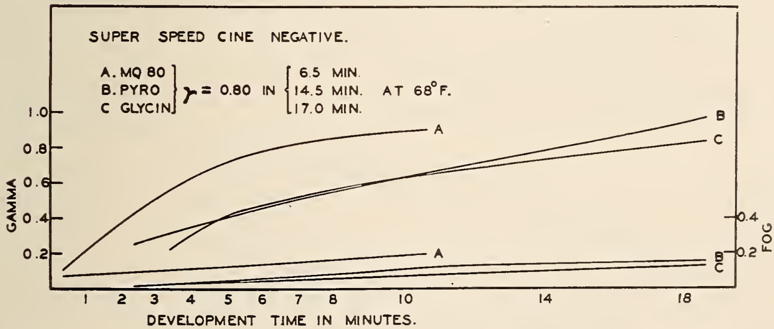


FIG. 27. Time-gamma curves in different developers with motion picture Super Speed negative film.

behavior of panchromatic film during development is very similar to that of Super Speed negative film both as regards the rate of growth of image density and fog. For shorter times of development both Super Speed and panchromatic film give less contrast than Par Speed film but the limiting contrast obtainable with all three emulsions is about equal.

Referring to Fig. 6, the angle which the characteristic curve of the emulsion makes with the log E exposure axis is a measure of the contrast of the negative image and this angle is termed gamma. Gamma or contrast increases with time of development up to a certain limit when the rate of growth of fog exceeds the rate of growth of the image, beyond which it is undesirable to go.

With a given developer, different emulsions vary as regards the contrast of the image obtained after developing for a fixed time. Also for a given emulsion different developers vary according to the

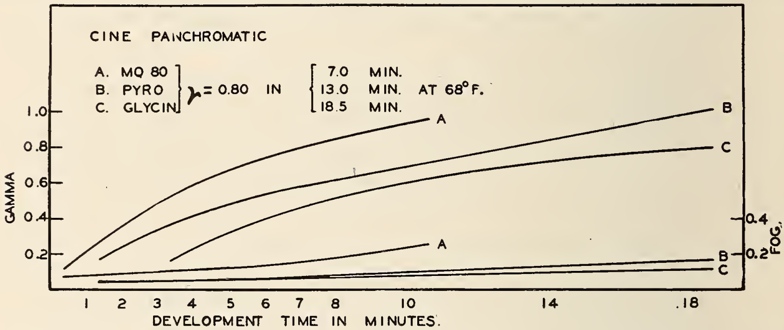


FIG. 28. Time-gamma curves in different developers with motion picture Panchromatic negative film.

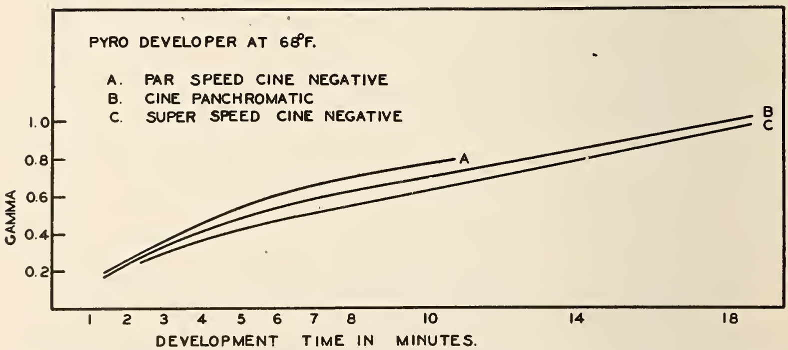


FIG. 29. Time-gamma curves for Par Speed, Super Speed and Panchromatic motion picture film in a pyro developer.

contrast which they produce in a given time. It is possible to study the behavior of different emulsions towards different developers by plotting the gamma or contrast against time of development. Such time-gamma or development-contrast curves are given in Figs. 26, 27, 28, and 29. From Fig. 29 it is seen that with fairly complete development (10 minutes) the contrast obtained with panchromatic film is slightly greater than with Super Speed film and slightly less than with Par Speed film. With the pyro developer in question 8 minutes development with panchromatic film will give the same contrast as 10 minutes development with Super Speed film. In general, panchromatic film requires slightly longer development than Par Speed film and slightly less than Superspeed film.

With Par Speed film gamma increases more rapidly with shorter development but the ultimate contrast obtainable is approximately equal in all cases.

An average negative on panchromatic film is usually developed to a gamma of 0.8. Referring to Fig. 28 this degree of contrast is obtained in 7 minutes with the MQ-80 formula, 13 minutes with pyro, and 18½ minutes with glycin at 68°F with fresh developing solutions. The developer formulae and instructions for developing motion picture film by the reel and tank systems have been given in a previous communication.[8]

The curves at the bottom of each figure show the rate of growth of fog with time. For a fixed contrast pyro, glycin, or MQ-80 developers give approximately the same fog so that there is little to choose between these developers. It has been shown that if there is a tendency for aerial fog by virtue of exposure of the film to the air as a result of frequent examination of the film during development, a pyro developer or one containing pyro is to be preferred on account of the anti-aerial fogging action of the oxidation products of development.

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DISCUSSION

Mr. Davidson: Isn't there a general impression due to the high contrast with the ordinary film that the panchromatic film is flat and does not give the depth that the ordinary film seems to give? Is this through lack of proper handling or is that a weakness in panchromatic film?

Mr. Jones: That is certainly due to improper handling. The characteristic curve of panchromatic film is practically identical with that of Par and Super Speed films. As a matter of fact, the panchromatic film usually gives slightly more contrast when developed for the same length of time in the same tank of developing solution.

As regards the criticism that the panchromatic film has not the density giving power, I think that is unwarranted, because panchromatic film does give as much or more density as the Par and Super Speed film.

Mr. Norling: I have found that panchromatic gives as much or greater density, but at the same time we have had some trouble with slight graininess over that of ordinary negative. That is probably due to some fault in manipulation in the laboratory, but I should like to have it explained.

Mr. Crabtree: In connection with our work on desensitizers, we found that with certain emulsions, in the presence of a desensitizer, on exposure to radiations of certain wave-lengths the developed image showed pronounced graininess. Apparently the latent image on the finer grains of the emulsion was destroyed. This would suggest that possibly under certain circumstances desensitizers which are formed when a developer oxidizes, may possibly be responsible for abnormal graininess. Much more work will have to be done before we can definitely say that excessive graininess of a negative is due to this cause. It has always been assumed that excessive graininess was an incipient form of reticulation produced by faulty drying. We are now certain however that there are other factors involved and we are working on the problem.

Mr. Hubbard: Is there any particular developing agent which is better for panchromatic stock?

Mr. Crabtree: As far as our experiments go, the developers which are satisfactory for SuperSpeed and Par Speed negative are equally suitable for panchromatic film.

Mr. Senner: What is the shortest instantaneous exposure possible with the Panchromatic K negative, F filter and the 3.5 lens under ordinary sunlight conditions?

Mr. Jones: We have made motion pictures (16 pictures per second) under average sunlight on Panchromatic K at F/2. The filter doesn't make much difference because the film isn't sensitive to anything in the visible spectrum. It has no sensitivity through the green, yellow, orange, and visible red, so that any filter cutting in this region is as effective as deep red.

Dr. Hickman: The value of Mr. Jones' lecture is that it shows people how to get exact tone reproduction. This is an essential preliminary, but does it go far enough? Is exact tone reproduction what the motion picture engineer is after? If you were to ask anybody which of these (indicating two pictures of oranges and lemons on slide) they would choose, they would take the upper (on non-color sensitive material). My thesis is that we have a definite convention in recording color so that certain of them shall stand out by contrast. If we have a young lady with golden hair in a pink dress against a blue background, although she would be very startlingly distinguished from her surroundings visually the panchromatic plate might quite correctly, from a scientific standpoint, render all the parts of the picture with the same tonal value and a hopelessly flat photograph would result. Your studio decorator surrounds his subject with colors warm and cold, knowing that red will photograph dark and blue light. With his color correct film, his set might be devoid of contrast unless he is able to think "color" in terms of monochrome. Because of its ability to render flesh tints without make-up and the improvements it gives for outdoor scenery I am an ardent supporter of panchromatic film. But to avoid disappointment I think the user should not only be taught how to obtain correct color rendering, but told how to falsify the rendering with the deliberate intention of emphasizing whatever tonal item of his subject happens to be the most important.

Mr. Jones: The point raised by Dr. Hickman is discussed in the text of the paper although I did not touch upon it in this presentation. He is entirely correct in stating that there are conditions under which a correct reproduction of tone would not be satisfactory. The visual impression of contrast resulting from the observation of a colored object is due to three different factors; brilliance contrast, hue contrast, and saturation contrast. It is quite possible to have two adjacent areas which are of identical brilliance contrast, but, by virtue of hue and saturation contrast, are sharply differentiated visually. It is obvious that perfect tone reproduction in a photograph would not be satisfactory since the two areas in question would appear identical. It is necessary therefore to introduce a distortion in order to obtain satisfactory photographic reproduction of the visual contrast. This can be done by use of a selective absorbing filter which will make one of the areas darker than the other and either color can be rendered as darker depending upon the discretion of the operator. It is usually considered best practice to distort the tone reproduction in such a way that the "warmer" of the two colors is rendered as lighter than the "colder" color. This follows as a natural consequence from our usual experience that the so-called warm colors (including reds, orange, yellows, and yellow-greens) are visually very much brighter than the colder colors (the violets, blues, blue-greens, and greens). Obviously it is quite impossible in a short time available for the presentation of a paper to deal with all of the intricacies of this subject.

PROF. WALL: Has any more work been done on aerial haze since the monograph on the subject?

MR. JONES: Nothing has been done recently in our laboratory relative to aerial haze. The work was done during the war in connection with airplane photography.

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OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

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Volume X, Number 28

MEETING OF OCTOBER 4, 5, 6, 7, 1926

BRIARCLIFF, 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.

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REFLECTION CHARACTERISTICS OF PROJECTION SCREENS.

Loyd A. Jones and Clifton Tuttle.*

SINCE the publication in 1920 of a paper by one of the present authors and Milton Fillius,[1] a large amount of data relative to screen surfaces now being manufactured has been gathered by this laboratory. This work was done largely in response to the urgent request of Mr. F. H. Richardson who assisted materially in the collection of samples from the various screen manufacturers. These data have already been published in part by Mr. Richardson in his "Handbook of Projection" and in the columns of the Moving Picture World.

As it may be of value to have these data available in the Transactions of this Society, and since certain further conclusions may now be drawn regarding the specification of projection screens from a consideration of their optical properties, it seems worth while to communicate the results at this time.

Two factors are of interest in the investigation of the suitability of a screen surface from the point of view of its optical properties. The first is the distribution of light from a single point on its surface to various members of the audience seated throughout a wide angle in front of the screen. The second is the distribution of light from various points on the screen surface to a single point of observation in the auditorium. Although it is true that non-uniformity in the distribution of light over the auditorium by a surface material is coincident with non-uniformity of brightness distribution over the picture surface as viewed from a single position, it seems best to consider the two factors separately. The uniformity tolerances in one case are not necessarily the same as in the other.

Uniformity throughout the theater.

As far as the first factor is concerned, the amount of diffusion required of a surface is determined by the dimensions of the auditorium. In the simple case of a rectangular auditorium, the size of the angle, within which a satisfactory distribution must be effected,

* Research Laboratories, Eastman Kodak Co.

[1] Loyd A. Jones and Milton F. Fillius, Reflection Characteristics of Projection Screens. "Transactions" S. M. P. E. No. 11, 1920, p. 59.

is fixed by the width of the theater and the distance of the screen to the first row of seats. The extreme end seats of the first row are at the greatest angle from the screen and if the theater manager wishes to use these seats he should provide a screen that is capable of spreading light to them. Obviously no one type of screen surface can fit all theaters with maximum efficiency. If the auditorium is narrow, a screen of the completely diffusing type, i.e., one which reflects light very uniformly in all directions, is wasteful. Light which is reflected outside of the angle required only adds to the general illumination of the theater. Such overflowing illumination may be either harmful or beneficial depending upon other circumstances; but in any case it is inefficient to supply this extra light by means of the projector. On the other hand, if a screen of specular type, i.e., one which concentrates the reflected light within a narrow angle, is used in a wide theater, one of two results is sure to follow: either those occupying seats toward the front and at the side of the house will see a picture of low brightness, or if it is made bright enough for them by increased amperage in the projector, it will be needlessly bright for those in the center and may result in excessive visual fatigue owing to glare. Thus we see that for a screen surface adapted to a particular house, the brightness of the picture as seen from the center aisle should not be greater than the side seat brightness by some limiting factorial value.

Uniform brightness from a single point.

The second factor is independent of the size of the auditorium, a screen will show the defect of non-uniformity just as badly in a narrow theater as it will in a very wide one. It can be shown mathematically that the maximum difference between the angles at which one sees the two edges of a picture occurs when one is on a line perpendicular to one edge of the screen. As the observer moves toward the screen along this perpendicular line, the difference becomes greater and greater. Since the brightness of all commercial screen surfaces depends to a greater or lesser extent upon the angle at which the light is reflected, the difference in *angle* just referred to is always accompanied by a difference in *brightness* between the sides of the picture.

The fundamental data of interest in an investigation of either of the factors referred to are found by measuring the intensity of the reflected light as a function of angle of reflection.

Method and Apparatus.

The method adopted consists in measuring the brightness of the surface under examination when illuminated normally by approximately parallel light and viewed at various angles of observation. The reflection coefficient varies somewhat as the angle of incidence is changed becoming greater for greater incident angles. However, for the screen surfaces which were measured, it was found that the increase in brightness at angles of observation which occur in practice, was less than 10 per cent for a change in the angle of incidence from 0° to 15°. Since in theater projection the incident angle is rarely over 15°, it may safely be assumed that the data given will hold with sufficient accuracy for the computation of brightness under practical conditions of incidence.

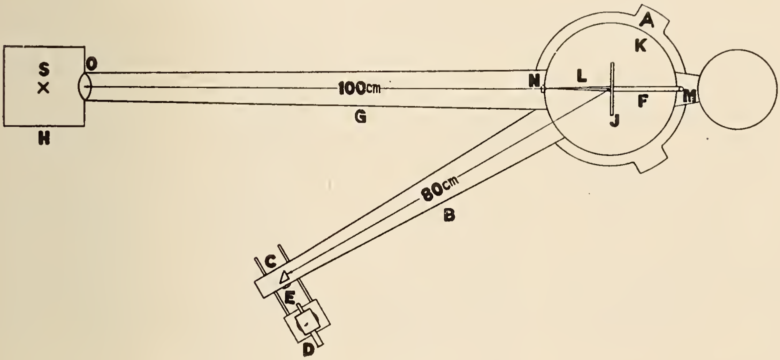

FIG. 1.

The essential parts of the instrument used are shown in Fig. 1. As this instrument is in principle exactly the same as the one used in the previously reported investigation it will be only briefly described here. A cast iron base *A* supports the arm *B* at the end of which is carried the photometric apparatus. In order that the observer and the photometric equipment shall not interfere with the illumination of the sample at angles closely approaching the normal, the axis of observation is bent at right angles by the prism *C*. An especially constructed photometer of the illuminometer type is mounted at *D*. A rigid bearing *E* supported by the base-casting carries a movable arm *G* on one end of which is mounted the lamp house *H*, while at the other end a counter-poise weight *I* is placed. A holder for the sample *J* positions the surface of the sample in the axis of rotation of the arm G. A circular scale plate K is mounted in a fixed position relative to the base A. A pointer attached to the sample holder indicates the angle on the divided scale plate. By

Table 1

No.	*Class*	*Manufacturer*	*Trade Name*	*Texture*	*Color*
1	C		Magnesium carbonate	Smooth	White
2	C	Lockwood	Cotton sheeting	Fine grain	White
3	C		2 coats mill white paint on cardboard	Smooth	White
4	C		Calendered cardboard	Smooth	White
5	C		Plaster wall surface Kalsomine	Smooth	White
6	C		Wallboard with 2 coats gold leaf bronze	Smooth	Metallic yellow
7	C		Wallboard with 2 coats aluminum paint	Smooth	Metallic white
8	A	L. J. Gardiner Co. " "	Gardiner Velvet Gold Fibre Screen grade No. 1	Pebbled	Metallic yellow
9	A	"	" " 3	Coarse grain	Metallic yellow
10	A	"	" " 4	Smooth	Metallic white
11	C	"	" " 5	Fine grain	White
12	B	C. S. Wertsner & Son	Superlite	Pebbled	Metallic white
13	B	"	Keystone	Fine grain	Metallic white
14	B	"	Special silver	Pebbled	Metallic white
15	B	Da-Lite Screen & Scenic Co.	Peerless	Coarse grain	Metallic white
16	A	"	Golden Fleece	Coarse grain	Metallic yellow
17	C	"	Crystal white	Fine grain	White
18	A	"	Mazdalite	Coarse grain	Metallic white
19	C	Walter G. Preddey	Simplicity	Smooth	Metallic white
20	C	National Screen Co	Master White Tone	Smooth	White
21	A	"	Master Glass Bead No. 5	Medium beaded	White
22	C	"	Master Glass Bead No. 7	Small beaded	White
23	A	Raven Screen Corp.	Mirrortone	Coarse grain	Metallic white
24	B	"	Silvertone	Coarse grain	Metallic white
25	C	"	Singletone	Fine grain	White
26	C	"	Mazda Haftone	Fine grain	White
27	C	"	Haftone	Fine grain	White
28	C	"	Painted	Fine grain	White
29	A	Minusa Cine Screen Co.	DeLuxe Special Matte	Pebbled	Metallic white
30	A	"	DeLuxe Special Ingrain	Pebbled	Metallic white
31	A	"	DeLuxe Special Pebbled	Pebbled	Metallic white
32	A	"	DeLuxe Special Smooth	Smooth	Metallic white
33	C	M. Major	Majorlite Magnesium Screen Coating Paint	Smooth	White
34	C	Raven Screen Corp.	Amisilk face out	Smooth	White
35	C	"	Amisilk face in	Smooth	White
36	A	Victor Holoplastic Screen Co.	Victor Holoplastic	Smooth	Metallic white
37	B	Spencer Lens Co.	Spencer Luminex	Smooth	Gold
38	A	Walker Sunlight Screen Co.	A Sunlight	Grained	Metallic white
39	A	"	B "	Grained	Metallic white
40	A	"	H "	Grained	Metallic white

removing a pin M, the sample-holder can be moved independently so that the angle of incidence can also be changed if desired.

The results are expressed in terms of the reflecting power of magnesium carbonate at normal illumination and observation as 100 per cent. The particular block of magnesium carbonate used had a coefficient of total reflection of 0.98 when measured in a reflectometer of the integrating sphere type.

Data showing the relation between brightness and angle of observation.

The materials examined are listed in Table 1. In the case of commercial screen surfaces, the trade name applied by the manufacturer to the screen is used. The terms relating to texture and color are necessarily only qualitative statements of these characteristics.

Table 2 shows the reflection characteristics of the materials examined. The angle is varied only from 0° to 50° since this is the limit of practical usefulness of such data. The effects of distortion are so great for any observational angle greater than 50° that there is no practical use of having theater seats placed beyond this angle.

The accuracy of the data of Table 2 is limited by: (1) non-uniformity of the surfaces; (2) error in angle setting; (3) error of photometric setting; and (4) variation of line voltage resulting in non-proportional variation of the two lamps. These various factors were isolated and a number of readings were made to determine the magnitude of each effect. The results are summarized below:

Kind of Screen Tested	*Maximum Variation from Mean*
(1) Typical specular (metallic coating on cloth)	8.6%
(1) Typical diffuse (flat white paint)	2.9%
(2) Typical specular	5.4%
(2) Typical diffuse	0.0%
(3) For any surface	1.3%
(4) For any surface	1.3%

It is probably safe to assume that the data in Table 2 are correct to within ±5 per cent, although manufacturing differences between individual screens, especially those of specular type, may amount to greater variation.

TABLE 2.

No.	0°	5°	10°	20°	30°	40°	50°
1	100	100	100	99	98	98	97
2	61	61	60	59	58	57	56
3	80	79	78	77	76	74	70
4	113	109	106	94	83	80	79
5	82	82	82	81	81	81	81
6	132	125	115	88	66	50	37
7	163	150	134	93	61	43	31
8	414	361	295	153	71	32	17
9	436	385	319	161	73	34	20
10	427	380	300	163	73	36	18
11	80	79	77	74	69	68	68
12	301	281	240	140	76	43	64
13	274	255	223	132	73	43	28
14	271	244	205	132	77	45	22
15	220	200	173	115	68	40	22
16	357	315	264	149	73	38	24
17	76	75	74	73	72	71	30
18	338	305	252	129	75	42	61
19	151	139	125	89	60	43	29
20	78	77	77	76	75	74	73
21	291	273	204	83	55	48	47
22	217	205	167	89	63	55	51
23	357	328	280	145	66	36	21
24	228	215	194	140	83	54	35
25	80	79	78	76	74	72	69
26	82	80	79	75	71	67	63
27	82	80	79	76	72	69	66
28	72	71	70	68	66	64	63
29	450	417	324	150	67	35	22
30	348	280	210	105	58	31	18
31	319	281	231	130	69	37	21
32	436	347	269	127	60	43	20
33	95	95	94	93	91	88	85
34	86	86	85	83	82	80	76
35	84	83	80	74	69	64	61
36	427	370	268	143	74.3	36.2	20.9
37	356	319	281	174	96.5	48.8	33.4
38	412	374	320	157	70.5	33.3	21.6
39	519	413	271	125	55.7	30.8	19.2
40	350	326	282	168	82.0	40.0	24.0

Analysis of results.

In order to facilitate the use of these data certain computations have been made, and a grouping into classes has been attempted. In our previous discussion, we have outlined two factors for consideration. The acceptance of a screen as the basis of either of these factors depends upon the ratio of brightness at some limiting angle to the brightness of specular (0°) reflection.

From what we know of the contrast sensibility of the eye, sensitivity to fatigue by glare, and other physiological factors, we judge that a screen optically fitted to the theater should not have a brightness for the center aisle greater than four times the brightness for the end seat of the front row. Our classification of screens is made on this basis. Screens having a brightness ratio from 0° reflection to 30° reflection greater than 4 are judged too specular for a house of medium width (one in which the front row of seats subtends an angle of 60° at the center of the screen) and are placed in class A. Screens whose 0° to 40° ratio is over 4 are judged too specular for wide houses and are placed in Class B. Screens which diffuse the light so well that the ratio of 0° reflection to 40° reflection is less than 4 are suitable for wide theaters and are listed in Class C. The point should be emphasized that these classifications are not rigid but are of only an approximate nature.

In Tables 3, 4, and 5 the columns headed R give the arithmetical mean of the reflection from 0° to 20°, 30°, 40°, and 50°. These values are indicative of the amount of light reflected within the limiting angles stated at the head of the columns and provided the distribution which is indicated by the ratio is satisfactory, it can be stated that the screen having the highest R value will prove most efficient optically.

The application of these tables to a particular problem in fitting the auditorium with a screen which will give proper distribution of light to all seats can be made more clear by the use of an example.

Suppose that we have the following dimensional data concerning a theater:

Length of first row of seats	24 ft.
Distance of this row from screen	20 ft.
Projector, audience, and screen all on same level.	

The problem, simply stated, is this—what is the greatest angle at which a patron of this theater can see the center of the screen.

TABLE 3.

Class A.

Surface No.	*Ratio*	*20° R*	*Ratio*	*30° R*	*Ratio*	*40° R*	*Ratio*	*50° R*
8	2.70	306	5.83	259	12.0	221	24.3	192
9	2.70	325	5.97	275	12.8	235	21.8	204
10	2.62	318	5.85	269	11.9	230	23.7	200
16	2.39	271	4.89	232	9.38	199	17.0	174
18	2.62	256	4.50	220	8.04	190	15.4	166
21	3.51	213	5.28	181	6.06	159	6.19	143
23	2.46	278	5.41	235	9.92	202	17.0	176
29	3.00	337	6.72	282	12.8	231	20.2	209
30	3.31	236	6.00	200	11.2	172	19.4	150
31	2.47	230	4.62	206	8.62	178	15.2	156
32	3.43	295	7.26	248	10.1	214	21.8	186
36	2.98	302	5.74	256	11.8	220	20.4	191
38	2.63	316	5.85	267	12.4	278	19.1	198
39	4.15	332	9.32	277	16.8	236	27.0	205
40	2.08	282	4.27	242	8.75	208	14.6	182

We can solve this problem graphically by laying off the distances to scale and measuring the angle required with a protractor (see Fig. 2). Or if we have a trigonometric table at hand, we can compute this angle. The angle required is the angle whose tangent is

$$\frac{12 \text{ (distance of seat from center)}}{20 \text{ (distance of first row from screen)}} = 0.60.$$

From the table of tangents this angle is found to be about 30°. Knowing this maximum angle, we should expect to find a suitable screen in Class B. For we know that all screens in Class A have a 0° to 30° ratio greater than the allowable 4. Also we know that Class C screens are sufficiently diffusing for use in a house whose maximum angle of observation may be as much as 40° or more. All of the screens in Class B fulfill the ratio requirement. Making a choice is largely a matter of deciding

TABLE 4.

Class B.

Surface No.	*Ratio*	*20° R*	*Ratio*	*30° R*	*Ratio*	*40° R*	*Ratio*	*50° R*
12	2.15	241	3.96	208	7.00	180	13.1	158
13	2.07	221	3.75	191	6.37	167	11.4	146
14	2.05	213	3.50	186	6.02	162	10.4	143
15	1.91	177	3.24	155	4.78	136	9.16	120
24	1.63	194	2.74	172	4.22	152	6.52	136
37	2.04	283	3.69	245	7.28	213	10.65	187

Table 5.

Class C.

Surface No.	Ratio	*20°* R	Ratio	*30°* R	Ratio	*40°* R	Ratio	*50°* R
1	1.01	99.8	1.02	99.4	1.02	99.2	1.03	99.0
2	1.03	60.2	1.05	59.8	1.07	59.3	1.09	58.9
3	1.02	78.5	1.03	78.0	1.04	77.3	1.05	76.3
4	1.07	105	1.12	101	1.16	97.5	1.19	94.9
5	1.01	81.8	1.01	81.6	1.01	81.5	1.01	81.4
6	1.06	115	1.26	105	1.38	96	1.51	87.6
7	1.21	135	1.36	120	1.52	107	1.72	95.0
11	1.08	77.5	1.16	75.8	1.18	74.5	1.18	73.7
17	1.04	74.5	1.06	74.0	1.07	74.5	1.10	72.9
19	1.70	126	2.52	113	3.51	101	5.03	91.0
20	1.03	77.0	1.04	76.6	1.05	76.2	1.07	75.7
22	2.44	170	3.44	148	3.94	133	4.25	121
25	1.05	78.2	1.08	77.4	1.11	76.5	1.16	75.4
26	1.09	79.0	1.15	77.4	1.22	75.7	1.30	73.9
27	1.08	79.2	1.14	77.8	1.19	76.3	1.24	75.0
28	1.06	70.2	1.09	69.4	1.12	68.5	1.14	67.7
33	1.02	94	1.05	93	1.08	93	1.12	91
34	1.04	85	1.05	83	1.08	84	1.13	83
35	1.14	79	1.22	77	1.31	75	1.38	73

on price, durability, and other factors. The *R* column of this table gives interesting information about the efficiency of these screens. It indicates the average of reflection ordinates from 0° to the limiting angle. Screen No. 12 has the highest *R* value which means that it would reflect the most light within the required angle. Nos. 13 and 14 also show very high average reflection.

The foregoing example of the computation of angle of observation is based on assumptions which are not usually fulfilled in actual theater installations. In most theaters the projector, audience, and screen are not all on the same level and the screen is often inclined from the vertical to compensate the keystone effect. The graphical solution of the more complicated case may be found by construction of a three dimensional model. The mathematical solution consists in expressing the unknown angle in terms of the angular coordinates of a spectator and the angle of regular reflection. The relation to be used is the cosine rule of spherical trigonometry.

The Criterion of Uniformity.

The cause of non-uniformity of the screen image due to differences in the direction of observation in which one sees the right and left edges of the screen is illustrated in Fig. 3. The line AB represents a screen at a distance X from the projector P. PA and PB represent the direction of the boundary rays from the projector. AR and BR' show the direction of the specular component of reflection. For all of the screens thus far examined, the maximum brightness difference between edges will occur for an observer in the line of specular reflection from one edge. Now suppose that the observer is stationed along the line BR' at a perpendicular distance d from the screen.

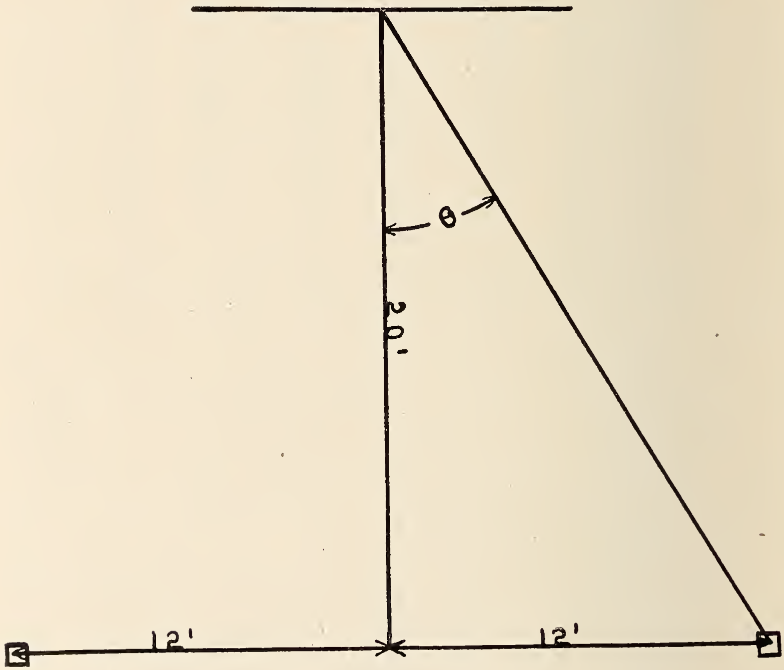

Fig. 2

From the point B he receives specular reflection, that is, the highest brightness of which the screen is capable. From A he receives a component of reflection at an angle θ from the specular component AR. The size of this angle depends upon the width of the screen, the distance of the observer from the screen, and the length of throw of the projector. Because of these variables, every installation would present a slightly different problem, but it seems reasonable to demand that any good screen should have characteristics which should enable it to give a fairly uniform picture under an unfavorable set of conditions. Let us assume such a set of conditions a short throw, say 70 feet, resulting in a large angle of incidence for the boundary rays, a relatively large screen for so short a house, say 12 feet, and a short distance to the nearest row of seats, say 17 feet.

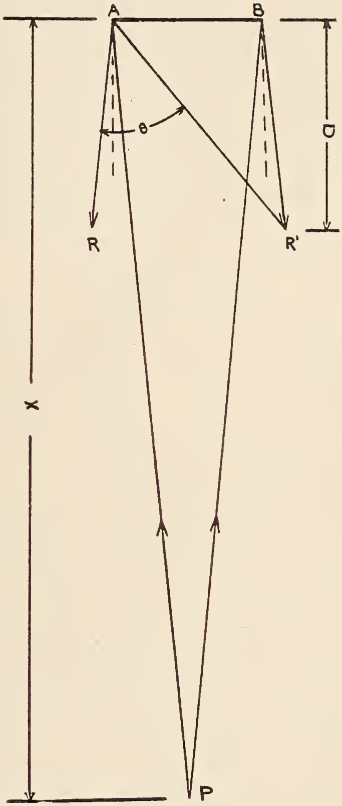

FIG. 3.

The angle θ of the angle at which the farther side of the screen must reflect light to the observer is then equal to about 40°. The ratio of the coefficient of reflection at 0° to that at 40° may then be adopted as a criterion of uniformity. Such a criterion should be considered effective for all screens irrespective of the width of house in which it is to be used. The non-uniformity would be just as bad in a very narrow house as it would in an exceedingly wide one. It would be slightly less in a house with a long "throw" but the projection distance is a factor of only secondary importance.

The limiting value of brightness ratio is exceedingly difficult to establish. Some physiological investigation is in progress which will make the acceptable limit of this ratio more definite, but for the present we can merely express an opinion that the ratio should not in any case exceed 10 and preferably it should be much less.

Many other factors such as durability, initial cost, color, and style of mounting, affect the choice of a screen. The points which we have described here are optical considerations only. Disregard of the matters which we have considered as essentials, equality of distribution and uniformity, are however certain to result in poor quality pictures for some members of the audience.

DISCUSSION.

Mr. Roos: What effect does variation in the size of the screen have? Were these screens of any particular size?

Mr. Tuttle: The size of the screen has no effect on the tables shown. The tables show data connecting the angle of observation and brightness. The angle of observation for a given theater and given size of screen must be calculated for each case. Knowing the angle, one can find the brightness from the tables.

Mr. Roos: As I understand it, the angle is based on the center or left of the screen, if it were 20° in diameter—the angle would be more severe at the edge than if it were a 10° screen.

Mr. Tuttle: That is true. Every installation requires separate computation. The table that I showed gives the ratio of the zero degree; that is, specular reflection, to the reflection at various angles

Mr. Richardson: I think one of you is talking about one thing, and the other is talking about something else. I think these tables are designed to set up a series of data by which the engineer may know what the effect will be from any seat in the house.

Mr. L. A. Jones: The data given in the tables show directly the relative values of screen brightness at various angles of observation. They were obtained with a beam of collimated light incident normal to the surface of the sample. Measurements of screen brightness were then made at various angles from the normal. They therefore represent directly the relative brightnesses of the center of the motion picture screen as observed at different angles from the normal to the screen surface, it being assumed that the axis of projection is also normal to the center of the screen. The data may be used however to compute the brightness of the edge, or any specified point, of the screen as observed from any specified angle. The method of doing this is illustrated in Fig. 3. The lines AR and AR' represent the direction of specular reflection from the screen edges. If now an observer is seated on the line BR' the right hand edge of the screen will have a brightness as indicated by the 0° value in the table. If he is seated at some point off of the BR' line, let us say at such a point that the line drawn from his eye to the right hand edge of the screen, point B, makes an angle of 10° with the BR' line, then the brightness of the right hand edge of the screen will be as indicated by the value in the 10° columns of the tables. As Mr. Tuttle stated previously, this is not strictly true but the deviations between values computed in this way and those actually measured are less than 5 per cent and therefore for all practical purposes negligible. The size of the screen certainly has an important bearing on this since it determines the angular values just mentioned. When a motion picture is projected on the screen the angle of incidence varies from point to point on the screen and for any single observer the angle of observation varies from point to point. If we should attempt to tabulate for all possible conditions including such variables as length of throw, size of screen, position for observer, etc., we would have an extremely bulky series of tables. It seemed better, therefore, to merely give the basic data and let each engineer compute for any particular set of conditions the resultant distribution of screen brightness.

Mr. Hill: Mr. Tuttle has just assured us that this data will serve for any condition, but I should like to ask if the data holds true when the angle of incidence is acute; for instance, with a short focal length lens when you are observing the edge of the screen at a point remote from the axis?

Mr. Tuttle: We have made a number of measurements on the most specular screens to find the effect of varying angles of incidence upon the reflection. We find that up to 30° incidence, which is a greater angle than is encountered in practice, the increase in specular reflection is less than the photometric error of ± 2 per cent even when a short focal length lens is used.

MOTION PHOTOMICROGRAPHY.

George E. Stone.*

THE attempt to combine the microscope with the motion picture camera introduces many technical difficulties about which very little has been written. The result is that this branch of photography has been left largely to a few specialists who have had the technical knowledge and the enthusiasm to work out the details—each for himself. Yet the principles involved may be readily grasped and there is no reason why any serious worker, with a little patient application, should not be successful from the very start.

The exact limits implied by the term "Microscopic Motion Picture" is hard to define. A decided confusion exists within the minds of those who use the term, and this I shall hope, as an incidental contribution, to clarify. If the average camera-man were asked to give a definition he would undoubtedly reply, "A microscopic motion picture is one made through a microscope." But many of the finest microscopic films are not made with a microscope at all, so, for this loose definition, I should make bold to substitute the more exact one as follows, "A microscopic motion picture is one in which a small object is made to appear larger, on the screen, than when viewed with the unaided eye." Strictly speaking, my definition includes the many familiar "close-ups" which the dramatic and commercial photographers make daily as a matter of routine with little thought that they are applying the self-same principles which are the special study of the scientific microscopic photographer.

The professional cinematographer, who wishes to make an extreme "close-up", from long practice, does three things:

1. He moves close to the subject;

2. He racks the lens away from the film and toward the subject;

3. He increases his exposure to compensate for the enlarged image.

He knows, as a general principle, that the closer he approaches the subject, the further must he extend his lens and the more light must be secure for full exposure. He furthermore knows that he is free to use any lens on the camera turret but that the short focus lenses, while they give excellent "depth", must be placed very close

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to the subject so that a false perspective is secured which he usually refers to as "distortion." He knows, also, that the long focus lens will give equally large images from a greater distance with a gain in perspective. His choice is a compromise at which he arrives after considering the relative merits of his lens equipment and the conditions of his assignment. Yet such a typical photographer, presented the problem of photographing a house-fly, has asked me, "what lens shall I use, I have everything from thirty five millimeters to six inches."

For the scientific photographer, the simple law of "conjugate foci" will prove most useful. The familiar formula is as follows:

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}.$$

u and v represent the respective distance of the object and its image while f represents the focal length of the lens in use.

A simplified formula as stated in Cassell's Cyclopaedia of Photography is particularly useful. Whether enlarging or reducing, if F equals the focal length of the lens and R equals the ratio between the size of the image and the object then $F \times (R$ plus 1) equals the greater distance or major conjugate. This major conjugate divided by the ratio will give the lesser distance or minor conjugate. And in all cases where the image and the object are the same size, the major and minor conjugates are equal and are twice the focal length of the lens.

As a practical example, let us consider the relative merits of three different lenses when used to photograph a small object such as a bee. With a lens of 2 inch equivalent focus, an extension of 4 inches with the object also 4 inches from the lens will give an image which is natural size.

With a lens of 4 inch equivalent focus, an extension of 8 inches is required to give an image which is natural size and the object must be 8 inches from the lens.

With a lens of 6 inch equivalent focus, an extension of 12 inches is required and the object must be 12 inches from the lens, in order to give an image which is natural size.

It is well to remember that the minimum distance which may exist between an object and its real image is four times the focal length of the lens. Failure to remember this simple law is responsible for much wasted effort on the part of the beginner. The first operation in the photography of small objects is to arrange the apparatus so that it is possible to secure an extension between object and film which is at least four times the focal length of the lens which is to be used. This extension can never be less and for enlargement or reduction it will be more, so make all preparations accordingly and, if working space is limited, choose a lens of shorter focus.

To secure an enlarged image we have only to decrease the distance between the object and the lens and increase the distance between the lens and the image and the ratio of enlargement will be in proportion to these extensions. Thus to secure an image twice natural size the various extensions will be as follows:

The ratio is two and the focal length of the lens is 2 inches. Applying the formula: $2 \times (2 \text{ plus } 1)$ equals 6, the greater extension of the lens and 6 (this greater distance) divided by 2 (the ratio of enlargement) equals 3, which is the distance of the object from the lens.

For the 3 inch lens the extension must be 9 inches and the object must be $4\frac{1}{2}$ inches from the lens, and so forth.

It is apparent, that, as far as our problem is concerned, we are free to use any one of the three lenses either for natural size or for magnification but that certain practical considerations limit our choice. The short focus lenses do not give as good perspective and furthermore require that the lens be placed so close to the object that, in many cases, particularly with live subjects, it would be impossible to get them to pose. I have even found difficulty in lighting certain objects when so close to the lens due to the fact that the light is scattered into the lens, or the lens itself may produce a shadow on the object.

By personal choice, I choose a 3 inch lens for all-round work with insects. It gives good working distance without requiring so much extension as to cause trouble from vibration. Moreover, depth is usually sufficient for all practical purposes and perspective is good. The smaller, the insect, in general, the shorter the lens I use for most convenient work. Thus I should choose a 4 or 6 inch lens for grasshoppers or butterflies, a 3 inch for bees, a 2 inch for flies and a 35 mm. for small fruit pests, aphids, etc. There is nothing arbitrary about this recommendation and a variety of conditions may arise to affect the choice but, as a good working formula, it is probably not far wrong. Smaller objects are photographed with a compound microscope.

As practical examples, I may refer to Fig. 1 which shows a malarial mosquito in the act of biting. The dome-like object in the background is the knuckle of a human hand. This was a hurried job because the mosquitoes had been sent through the mail to the University and might not live long. Furthermore it was already past midday when I received the information. I hurriedly, took my 2 inch Carl Zeiss and fitted it into a small brass tube improvised in the crudest way but which permitted me to secure an extension of slightly less than 4 inches. The spiral focusing mount permitted a small degree of movement for focusing.

FIG. 1. Malarial Mosquito biting on human hand. Made with 2 in. Zeiss Tessar on a 4 in. extension (approx).

The narrative of this experience is largely biological but is interesting and probably useful to others who may attempt this type of work. It illustrates a certain alertness of observation which is vital to success in microscopic work.

The problem was to get the mosquitoes to bite under the microscope. At first, mosquitoes were placed in a glass test tube which was inverted upon the hand of a volunteer. The insects fluttered and buzzed about in the closed end of the tube but could not be made to settle down and bite. Then a few were liberated in a large insect cage where they had more freedom and an arm was thrust in among them. The insects still fluttered about and would not bite. Presently, one escaped and we followed its flight. Straight to the window it flew and, in the warm sunlight, buzzed its way about with its head against the glass slowly rising until it struck the top rail. Then it drifted slowly across the window into a heavy shadow from a stone buttress. Here, in the comparative coolness, its activities were slowed down and it dropped, by degrees, down the window until it presently disappeared beneath a laboratory table. Busy with other specimens—we suddenly were startled by the exclamation of a student who had been bitten on the ankle.

Here was our answer. We had now only to liberate the insects, one at a time and place a hand against the window just where a mosquito would settle upon it. In every case, they bit at once and could then be moved into the sunlight. When more light was added, as from a mirror, they immediately ceased feeding and flew away. I was therefore obliged to get my exposure by slow cranking.

It was impossible to do much focusing with the lens mount since the range of movement was too slight. Instead, I caused the volunteer to rest his hand upon a rod attached to a heavy metal base. This, he partially grasped and, by resting his elbow upon the table, was able to remain quite steady. I then looked into the camera, directly upon the film, and moved the hand and stand, as one, back and forth and to and fro across the table until the image flashed into view. A little movement was sufficient to refine the focus and I then quickly cranked the scene.

All of this had to be done quickly yet smoothly and without flurry because the insects were easily disturbed and the time was short. However, in less than an hour, some six successful views were obtained.

Figure 2 illustrates another extreme. This picture was made in 1915 in the Imperial Valley with a Dallmeyer telephoto lens of 8 inch focal length. This was attached to three lengths of threaded tube which gave a total extension of approximately 16 inches. It shows a wild grasshopper eating a blade of corn. The temperature was in excess of 117 degrees and the grasshoppers were so active that they flew or jumped when one approached to any normal photographic distance. The long focus lens was ideal because it permitted the camera to remain approximately 3 feet away. These distances are approximate only. I have no record of the actual extensions used while the negative element in the telephoto lens produces an image considerably larger than the extension would indicate. Here again, biological observation was essential to photographic performance.

I quickly discovered that, if one walked briskly through the corn patch, most of the grasshoppers would fly away. Occasionally one, for some reason, would remain—often crawling around the stalk to hide. Such an individual proved easy to manipulate. The stalk was braced by slender sticks carefully placed so as not to disturb the insect and this prevented excessive movements of the plant. Working very slowly, it was possible to make such preparations in a number of cases and even to spread a white cloth over another plant some distance beyond, to serve as a background. The grasshoppers then resumed feeding as the picture shows. In one case, a suitable back-

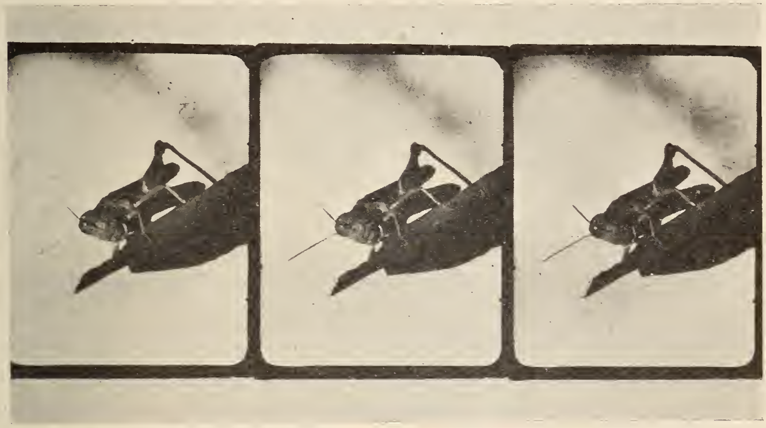

FIG. 2. Wild Grasshopper. Photographed with 8 in. Dallmeyer telephoto lens.

ground was arranged in advance and a convenient support provided I then cut a fresh stalk of corn and offered the cut end to all of the grasshoppers within reach. The majority avoided it, or flew away—but one, differently constituted, bit into it and fed so ravenously that I had no difficulty in carrying it to my camera and arranging my scene to my entire satisfaction.

It is with some hesitation that I include in this article such personal and biological details. They may seem to be a little foreign in a paper designed to be presented to engineers. However, I feel that there is full justification in including such details since the equipment to be used is largely dictated by the behavior of the subject to be photographed. Failure to observe biological details might result in wrong photographic and optical practice.

The most extreme use of camera extension to obtain magnification with which I am familiar was that of David and Marian Fairchild of Washington, D. C. Dr. Fairchild's work has become famous through the publication, by the National Geographic Society, of an article which was later published in enlarged book form and entitled "Book of Monsters." Dr. Fairchild used a "long focus lens"; the exact focal length is not published but from such data as is furnished, it must have been approximately 12 inches in focal length. This lens was mounted on the front end of a wooden box which was arranged with three sections so that it could be either 8, 12 or 24 feet in length. With this arrangement magnifications of from five to twenty diameters were obtained. Exposures varied from 50 to 80 seconds depending upon light conditions while a flash light was added to diffused sunlight in order to illuminate the shadows. The image was almost too dim to be seen on the ground glass and much too dim to focus sharply on such a glass. As a result, the image was sharpened by focusing with a high power glass, directly upon the aerial image.

A full description of the apparatus and the method of operation as well as a photograph of this unique camera, will be found in the introduction to the book.

Such bulky equipment and such lengthy exposures are out of the question for the motion picture man but the success of this method helps to disprove the fallacy which concludes that all "microscopic" motion pictures must be made with a compound microscope.

Before turning from the consideration of magnification produced by extension, it might be well to point out the theoretical and practical limits of the method. With a lens of 6 inches focal length a magnification of 100 diameters would require an extension of 50 feet while the object would be placed 6.01 inches in front of the lens. For a magnification of 1000 diameters an extension of 500 feet would be required and the object would be 6.001 inches from the lens. The limit of magnification for all lenses and real images is reached at a point when the working distance, or position of the object, is slightly less than the focal length of the lens, and in such cases the extension would be enormous. When the object distance exactly equals the focal length of the lens the extension and the magnification both become infinite which is an impossible condition and the rays become parallel without producing an image. When the object distance becomes less than the focal length of the lens, the image becomes virtual and may be viewed by the eye, as through a hand lens or reading glass, but cannot be projected as a "real" image which the camera can record. It should be further pointed out that even were such extreme extensions considered, the enlarged image would be quite unsatisfactory from the standpoint of detail. In addition to the mere property of enlargement, it is necessary to add the property of "resolution," in order to show detail. For example, the motion picture projector as used in a theater, is nothing less than a projection microscope by which an enlarged image is thrown upon the distant screen in accordance with the above principles. In spite of the enormous magnification, there is a decided loss in detail when the screen is viewed at close quarters, but this is due largely to the fact that the image is composed of silver grains. There is likewise a limit to the resolving power of an optical system. Beyond a certain point no increase in detail is secured by magnification.

Another consideration which has limited the use of lenses on long extensions to obtain magnification has been faintness of the image. Photographers who are interested in the theory of their craft all realize that the familiar F number on a lens is a definite measure of its light gathering power and hence its speed. The higher the F number the slower the lens by an amount which is indicated by the difference of the squares of the two numbers. The F number takes account of the effective aperture of the lens in relation to its focal length and it is thus a definite measure of the brightness of the pro-projected image. But few photographers stop to realize that the familiar rating is based on an extension equal to the focal length of the lens or, in other words, when the lens is in focus for distant objects. As the lens is extended for near objects the actual aperture remains the same but the ratio between aperture and extension constantly decreases so that the F number, as stamped on the lens, is no longer a guide for exposure.

A typical example will make this clear: A 6 inch lens with an effective aperture of 1 inch diameter is rated as F6 since the ratio of aperture to extension is as one to six. When however this same lens is extended to produce an image of natural size, the F value would be reduced to F12 because the lens is now extended to 12 inches. At a magnification of 10 diameters, the F value becomes F66 since the extension is now 66 inches. But under these different conditions the rated "speed" as stamped on the lens remains F6 and is often misleading.

A very important application of photographic principles has permitted one worker to do some remarkably effective work with insects. This man is said to make a comparatively small negative. That is, he makes no attempt to secure the full magnification on the original negative. This gives him great advantage in depth, improved perspective, and opportunity for greater exposure. He is then said to print by optical projection by which he gets the advantage of an enlarged positive from a small negative. An enlarged duplicate negative may thus be obtained which is far superior to any which might be obtained by direct photography. This same method of enlarging from small negatives has been used with marked success by "still" photographers of insects but I believe that its use in motion pictures has been limited to this one worker. The same effects may be obtained directly by the use of the "super microscope" which I shall describe later.

I have thus far considered images with small magnifications of from one to ten diameters but it must not be forgotten that an additional enlargement occurs when the films are projected on the screen so that, from the standpoint of the audience, such scenes present new and novel experiences in a little known world. I am familiar with the work of one man who has achieved an international reputation for "microscopic motion pictures" yet rarely does his work include a magnification even as great as two diameters. Most of his work is done with a lens of approximately 3 inches focal length and never does his work include any more complicated apparatus than the simple extension lenses which I have described.

I shall now discuss a type of microscopic photography more exacting in its technique of manipulation but which will permit photographs to be made of objects far too small to be seen by the naked eye and which may be so refined in its precision as to record details so minute that even the eye, equipped with the finest instruments, cannot discern the details. This instrument is known as the compound microscope.

First of all, I suggest that the beginner secure some of the simple books of instruction which are issued by the various manufacturers particularly Bausch and Lomb, Leitz, and Spencer. Later one should carefully study the book by our own member, Henry P. Gage, entitled "Manipulations of the Microscope." Another book to be studied for reference is Carpenter, "The Microscope and Its Revelations," which is still an excellent book although it was published more than thirty years ago. But above all things else, I wish to insist that the worker who expects to accomplish much with the microscope must become a student of the instrument. Rough, "rule of thumb" work with the microscope may produce some results but consistent results of technical excellence with a large variety of subjects will only come to the man who knows the instrument and knows it thoroughly.

The outstanding defect or limitation of the microscope is its lack of depth of field. This is a direct result of its enormous aperture or light gathering power. "Depth" or "Penetration" involves a vague sharpness in many planes so that one apparently looks into the fading distance. The great sharpness of the microscope is such, however, that only one thin layer of the subject may be viewed at one time and this with such distinctness that all other planes are eliminated. In fact, when viewing a transparent object, an effect is obtained known as an "optical section" by which a plane of the subject is so sharply in focus as to preclude all other portions. It is as though the object had been sliced by a microtome and one such slice only was under view. The skilled microscopist views such subjects with his hand constantly on the fine adjustment so that the lens travels slowly up and down—away and toward the object—by minute degrees and presents to him a composite picture of a solid object built up of separate plane sections.

The novice who first looks into a microscope is almost certain to be disappointed unless a specially prepared subject has been set for him. He usually expects to see a large image of a small object, while what he actually sees is more likely to be a small magnified portion of the object with so little of neighboring objects shown as to require explanation and interpretation.

Objects for the microscope must be kept as nearly flat as possible and as thin as conditions will permit. As a result, many of the finest subjects are those in which a film of liquid is provided between two glass plates in which living organisms move under observation. For the beginner, an excellent subject is the Paramecium, Fig. 3, a small form of animal life which is found in stagnant water. It is easily secured in abundant quantities, it is of convenient size and is quite hardy under rough manipulation. All in all, it is sufficiently "sure-fire" to give the beginner the needed encouragement of success at the start.

Place a few lettuce leaves or some dried grass or straw in a glass battery jar and fill up with water, preferably clean ditch or pond water. In a few days, after decomposition is well under way, the

Paramecia will make their appearance. They have developed from the dried "germs" or "spores" which were on the straw or grass left over from a previous generation of other Paramecia. Under favorable conditions they will become so numerous as to form a slight cloudiness in the water. Place the jar against the light, leave it undisturbed for some time, and then examine it carefully. The tiny swarming motes can just be seen against the light moving slowly through the water or collecting at the surface as a sort of "scum." Dip a pipette into the midst of such a swarm and secure a few drops of liquid. Here are the actors for your first micro-cinema drama.

FIG. 3. Paramecium from stagnant water. One specimen about to break in two and thus multiply.

The stage is well prepared as follows: Take a piece of the fine Japan tissue paper—provided to clean the lenses. Cut a small rectangle about the size of a postage stamp and, in the center, cut a small circular opening a quarter of an inch in diameter. Now spread this on a glass plate and smear it with vaseline rubbing it out and eliminating most of it but leaving the fibers filled with grease so as to be water proof. Now, with a pair of forceps, lift the paper and drop it onto a cleaned and polished glass slide pressing it down smoothly into contact with the glass. If this is well done the tiny opening will remain bright and clean without dirt or greasy smudge to obstruct the view.

Now, in this tiny opening, place a drop of water from the pipette, and gently lower a cover glass upon it. The water will spread out and fill the opening while the excess will run out at the sides. However, if these instructions have been carefully followed, a swarm of the Paramecia will be seen to swim about in this film of water between the glass plates; confined within limits and protected from crushing and evaporation by the thin waxed paper.

Now place the slide on the microscope stage and secure it firmly by stage clips. Shift the object until the circular opening in the paper comes above the opening in the stage. Turn the nose piece of the microscope and bring a low power objective—such as the 16 mm.—into place. Insert the two power ocular in the upper end of the instrument and pull out the draw tube to the indicated length called for in the instruction book provided by the manufacturer. Now, turn the flat side of the mirror upward and adjust it to various angles until the tiny aquarium is seen to be illuminated. Then rack the tube down until it is close to the slide and then, with the eye at the instrument, rack it slowly upward until the swarming Paramecia come into view. Then, with the fine adjustment, move the lens slightly up and down until the image is critically sharp. Now refine the illumination by shifting the mirror slightly—closing or opening the sub-stage diaphragm or racking the condenser up or down, until the greatest detail may be seen. Then turn the nose piece and bring an 8 mm. lens into place. Again move the objective close to the slide and again focus up until the image flashes into view and again use the fine adjustment to sharpen the focus. The Paramecia will now nearly fill the field of view and will be seen to swim gracefully about revolving smoothly on their long axis—a graceful and beautiful object.

Here is opportunity to try many experiments in illumination. A small rack and pinion moves the sub-stage iris across the field while a fitting permits it to be rotated in any angle. This gives an oblique illumination and brings out structures which direct light does not disclose. Swing out the diaphragm ring—open it wide—and insert the dark-ground stop by which all central rays are shut away and illumination is confined to a hollow marginal cone. Now, rack the condenser up and down and manipulate the mirror until the Paramecia are seen to swim like glowing objects against a field of grey or black.

Shallow as is the film of liquid, it is still too deep to be fully sharp throughout its depth so that the Paramecia, as they move about, continually pass above and below the critically sharp level to which the lens is adjusted. With practice, one soon learns to manipulate the fine adjustment with some degree of precision so as to keep the image sharp. Alertness and deftness without confusion are often essential to success at some critical moment so all of the manipulations should be rehearsed until they are so familiar as to be performed unerringly, and without hesitation.

Having become familiar with the microscope and its manipulation we shall now consider the requirements which are needed to adapt this instrument to the motion picture camera.

The first requirement is an optical bench to which the various units of the apparatus may be attached and maintained in accurate alinement. In its greatest refinement, such a bed consists of a pair of parallel metal bars or a single straight bar of triangular section to which the various units are attached, by means of fittings or riders. It is possible to release clamping screws attached to the fittings so that the various pieces of apparatus may be shifted along the bed to change their mutual positions as occasion demands. It is highly desirable that such a bed be hinged near the middle so that a portion of it may be raised and clamped in a vertical position. This permits the camera to be hung vertically above the microscope for certain manipulations or swung down into the direct optical axis when the microscope is also used in a horizontal position.

For the occasional worker, such elaborate facilities are not always available and, with ingenuity, they may be improvised in various ways. I recall some years ago some excellent photographs of blood parasites made at a great sanitarium in Michigan. When I asked to see the apparatus, I was shown a 12×12 wooden column in the basement which helped to support the building. To this had been nailed a wooden shelf on which was clamped a clinical microscope. Above—on the same column—this ingenious worker had fastened his camera, which was a home-made affair with a star and cam movement, and he had then connected the two by means of a sleeve of some dark material. For illumination he had secured from the sanitarium a small, quartz mercury vapor lamp designed for therapeutic purposes and, with this crude combination, he had secured a film which could scarcely be improved.

On the other hand, the apparatus of the pioneer worker, Dr. Comandon of Pathé Frères in Paris, consists of a casting not unlike a lathe bed. Upon this is placed a second bed of massive cast iron construction which resembles a guillotine. This holds the camera for vertical use. My own equipment is made up of heavy brass rods and castings but even these are entirely too light for the purpose and I must exercise great care to avoid vibration. There is simply no question that the man who attempts any great amount of photomicrography especially with high powers should select a bed heavy and rigid enough to absorb the vibration of a motion picture camera operating at any speed. For less critical work, at smaller magnifications, the equipment need not be so elaborate and no ingenious photographer should hesitate to use improvised apparatus in an emergency.

One of the fittings on the optical bench should be a sort of metal table to which the foot of the microscope should be firmly attached so that it cannot be knocked off or moved out of adjustment. It is important that this table be provided with an elevating screw so that the instrument may be raised or lowered as conditions require. Another fitting is provided by which the motion picture camera may also be attached to the bed. This need not be elaborate, as in some apparatus, to permit the camera to be swung away from the microscope. It is only necessary that the camera be rigidly attached to a base of such proportions as to bring the aperture exactly in line with the microscope when swung into a horizontal position.

As for the camera, any standard make will do but the smoother the action and the less the vibration the better. It is almost imperative that it be so constructed as to permit of direct focusing at the aperture either on the film itself or on a ground glass. The camera lens is removed and there is never any occasion when the camera lens need be used in conjunction with the microscope. This question is asked of me more frequently than any other. The complete microscope assembly is a substitute for the ordinary taking lens. The microscope is joined to the camera by means of a bellows so that not alone is a light-tight connection established, but the distance between camera and microscope may be varied.

Theoretically, the perfect light for photomicrographic work should be a point source. Practically, it must be as small as possible —of great intensity and with little heat; and such a light has yet to be developed.

I shall not go into the theoretical considerations which justify the use of a point source except to say that the smaller the source the sharper the detail recorded. The early workers in still photomicrography, and where time was not an object, used the thin edge of an acetylene flame or even a kerosene flame for fine detail with high power lenses and turned the broad side of the flame for lower powers with less fineness of detail.

The small pencil arcs with from 4 to 6 amperes capacity on direct current closely approximate the ideal as regards a point source of light and the heat which they generate may be largely absorbed by a water cell. However, with higher magnifications, more and more light is required with the resulting heat so great as to present a serious problem, not alone for injury to the organism under observation, but for the delicate lenses of the instrument as well.

Water cells are useful but inadequate for the higher amperage arcs and the problem of heat elimination at high magnifications still remains a very serious problem. Comandon curtails his light by means of a synchronized shutter mounted between the light and the microscope. This shutter is directly connected with his motor drive mechanism and is in turn connected with the camera by means of small shafting and universal joints. Thus his light reaches the microscope in a series of flashes so that the prolonged heating effect of concentrated light is avoided.

In the case of this French worker, such a refinement is doubtless justified since he has, no doubt, secured photographs of far greater magnification of living organisms than have ever been attempted by other workers. His work has dealt with living organisms such as those which produce syphilis and sleeping sickness and I have even been shown, by him, a film which records the complicated changes of the chromosomes within a dividing white blood cell. But all such work is so advanced and specialized as to be unique. Personally, in all my experience, I have never been called upon but once to equal such a magnification. For the lower powers of 50 to 200 diameters the problem of heat is not as serious as is generally supposed. A cold light would be advantageous—often I have killed my organisms from heat—more often they have refused to perform properly under such conditions of heat and light but only once have I melted the balsam of a lens or in any other way injured my apparatus by heat.

In my experience I have used many sources of light. A clock work arc by E. Leitz was my first lamp and much of my best work was done with it. However, it was always a source of annoyance to me since it would rarely remain in adjustment for more than 7 minutes. I worked without assistance and this light had a way of going out at critical moments which tried my patience to the limit.

Some form of arc of low amperage equipped with a revolving carbon and automatically controlled by motor would doubtless be a most convenient source of light for many subjects.

I have tried also the Nernst light, acetylene gas, and various sorts of incandescent tungsten lights including the 30 volt 30 amp. projection lamp. The weaker lights are extremely useful for still subjects where long exposures on the "one turn crank" are possible but for availability and convenient adjustment, I have preferred the 30 volt bulb. It has decided defects—its large source, its irregular pattern and unequal intensity over its area are all against it, but, with careful handling, it can be made to produce excellent pictures and I confess to a great relief of spirit in the thought that I have only to throw the switch to secure, immediately, a flood of light.

For several years my microscope has been idle for my activities have been elsewhere, but when I again fit up the equipment I intend to experiment with a small mercury vapor light single tube so arranged that the entire tube may be oriented in the optical axis of the microscope. By so doing, I shall obtain the advantage of the illumination from the whole column of glowing vapor confined to the small cross section of the bore of the tube. I believe that such an illumination will be almost ideal because it will be photographically active and remarkably free from heat. I do not present this as a discovery for I am almost certain that this type of illumination has been used before. The therapeutic lamp used by the amateur worker at the Michigan sanitarium worked exactly upon this principle and much of his success was due to the accidental selection of this light source.

But to return to secure ground, I shall describe the exact details by which I make my adjustments and I hope that the personal pronoun may be pardoned.

With the pencil arc, my practice is to raise the arc on the long rod which supports it until the horizontal carbon is in direct line with the microscope. Over the arc is placed a housing to cut off extraneous light, and, in front of the arc and attached to the housing, is placed a pair of meniscus bi-convex condensing lenses $4\frac{1}{2}$ inches in diameter. This combination is a happy one for it produces a beam which is remarkably free from color aberrations.

In front of the lenses, I place a glass trough on a stand. This contains water and helps to absorb the heat from the light. I do not make the mistake of adding alum to the water. This is an old and persistent fallacy, because, while alum crystals absorb heat, due to water of crystallization, a solution of alum is worse than useless. It absorbs only 1/10 of 1 per cent more heat than pure water and absorbs 15 per cent of useful light as against 10 per cent for pure water. This misconception has persisted too long and it is well that, as engineers, we should help to correct it. Between the condensing lenses and the water cell I place a large diaphragm attached to a metal rod. The sub-stage diaphragm on the microscope is now closed. The arc is struck and the entire assembly of arc, lamp-house, condensers, iris and water-cell is shifted back and forth; raised or lowered; until a cone of light is secured which just fills the sub-stage iris on the microscope. This spot of light should be clear and bright, without disturbing shadows or color bands and manipulation must be continued until this result is secured. In case any color is apparent, it is advantageous that the bluer cone be allowed to fall upon the center of the diaphragm while the reddish cone is on the outside. By so doing the hot rays are to a degree eliminated since they fall on the metal portions of the microscope and are not transmitted through the lenses. Now close down the large iris in front of the condensing lens until only a small opening remains and shift the diaphragm, if necessary, until this beam falls exactly upon the center of the sub-stage iris. Now open the sub-stage iris so that the beam is permitted to traverse the microscope.

These same directions apply to the use of the 30 volt tungsten lamp. However, the adjustment of the curved mirror in this lamp causes slightly different practice. I place a piece of white cardboard, cut in a circle, directly against the sub-stage diaphragm. With the large iris closed to a small opening before the condensing lens, I shift the lamp until the image of the coils exactly covers the circular card in the diaphragm of the microscope. I then shift the mirror, until the reflected image of the coils falls nicely between the projected images. The result is a fairly uniform pattern of illuminating coils which fills the entire circular opening.

I turn the nose-piece until a low power objective is in place and then look into the gate of the camera through the focusing tube. If all alinements are correct, the image of the distant diaphragm should be exactly in the center of the camera gate. It is, of course, out of focus until the microscope is racked to a correct position in order to sharpen it. However, if the spot of light cannot be seen, the microscope must be slowly moved about on its stand until the light spot flashes into view. It may be necessary to raise or lower the microscope stand or manipulate the light until the slender beam of light passes through the diaphragm in front of the condensing lenses; falls nicely upon the center of the sub-stage diaphragm of the microscope and then passes through that instrument to fall upon the center of the camera aperture. Such a condition is known as "critical illumination" and it must be secured before photography is attempted.

We shall make the assumption that we are to use a 16 mm. lens and a two power ocular and take for our subject the familiar slide of living Paramecia already described. For an object of this sort, and at such low magnification, it is not necessary to use the sub-stage condenser. This may well be swung out of the optical axis and the stage iris below the preparation closed, until all unnecessary light is cut away. I invariably photograph such subjects on orthochromatic film and use a green filter. I personally feel that I have secured better contrast by this method than when no filter is used. My filter consists merely of a sheet of bottle green glass secured from an art glass studio. It was almost an accidental choice made during experiments some twelve years ago and, for my occasional work it has proved entirely satisfactory. I use a piece large enough to rest in front of the water cell where the heat is least concentrated. Even then the glass occasionally breaks. I have tried gelatine filters and cemented filters and liquid filters but have always returned to the green glass. The only objection to the gelatine and the cemented filters is that they are usually so small that they must be placed at the sub-stage of the microscope where the heat is likely to ruin them. However, for our demonstration, we shall use the familiar "B" filter of Eastman.

Now, with the camera loaded, check up the various adjustments and focus the image directly upon the film, until the Paramecia are seen to move about across the film. Then, turn the crank a few turns at normal speed. Now close the camera shutter to half its former opening and crank a few more turns. Put out the light and develop the test strip. There should be no difficulty in securing exposure—in fact, the difficulty will be to avoid over exposure. Choose the negative which is a little thin but full of detail and it will give the most satisfactory print.

Having exposed this scene under the conditions indicated by the test exposure, it is proper to attempt a higher magnification. For this, the condenser should now be turned into place and the stage diaphragm opened to the widest extent to clear the condenser lens.

Turn the 8 mm. lens into position, trim and adjust the lamp and carefully refocus. This subject will require full shutter opening but is not difficult. Crank a few feet at normal speed and then close the sub-stage iris one third. Crank another strip and close the diaphragm until an opening remains approximately ¼ inch in diameter. Crank a few feet as before. Examination will undoubtedly disclose the fact that there is a great improvement in the penetration of the subject as the diaphragm is decreased. At full aperture, the excess of light floods the subject and drowns detail. In fact, it will be discovered that this improvement in penetration increases beyond the point where it is possible to secure full exposure at normal speed. The answer will be to crank more slowly to compensate for the decreased illumination. If the organisms move too swiftly at this magnification, make a new preparation and add a little white of egg or a little Irish moss to thicken the water and slow down the movements.

It will now be in order to describe the process of high magnification by "Dark Field Illumination." This is an extreme refinement of the principle used in the preliminary manipulations; namely, of cutting away all the central rays of the illuminating cone of light and utilizing for illumination only the hollow cone of marginal rays. In fact, when the adjustment is perfect, no direct light should pass through the instrument. Only that which has been reflected from the objects under observation is transmitted and such object thus appears self-luminous upon a dark ground. By the utmost refinement of this apparatus and with a condenser of special construction, it is possible to photograph colloidal particles, etc. The principle is the same as the familiar one which permits us to see the dancing dust motes in a beam of light which passes through a darkened room and it is a demonstrable fact that we can clearly see particles, thus illuminated, which are too small to be seen under ordinary illumination.

In the low magnifications which we have heretofore considered, the simple diaphragm with a central stop is sufficient. But for the high magnifications, involved in the photography of bacteria, this arrangement is too crude. Special condensers are provided which are perfectly designed for this one purpose and critical work should not be attempted without them. The lens to use is one of the "oil immersion" type preferably 2 mm. and such lenses are of high aperture. In fact, for dark ground purposes, they are of too great an aperture, since they admit light other than that reflected by the object. Accordingly, these lenses must be reduced in aperture by inserting a special diaphragm within the lens. This is known as a "funnel stop" because of its appearance. The lens is unscrewed and the funnel stop inserted between the elements and then reassembled.

For such work with the dark field it is well to use the microscope in a vertical position with the camera supported directly above. This means that the light must be reflected into the microscope by the use of the plane sub-stage mirror and the light must be raised or lowered accordingly. It will be most convenient if the light is lowered and the microscope is raised until the beam is projected horizontally direct upon the microscope mirror. It will simplify adjustments. Furthermore, it will be necessary to use a light of approximately 25 amps. capacity in order to insure sufficient illumination.

Now for the preparation. One of the simplest subjects is the study of bacteria and other parasites found within the human mouth. Historically the subject is interesting since such bacteria were discovered by means of simple magnifying glasses of high power, long before the discovery of the compound microscope. On a clean cover glass, make a small circle with a little vaseline—just enough to mark the glass. Within this circle, place a small drop of distilled water. Now, with a tooth pick, scrape the roots of the teeth and the tiny spaces between them, for a trace of white deposit which escapes even the most vigilant tooth brush. This white deposit rubbed out into the water will provide a remarkable collection of living organisms. A cover glass is then dropped over the smear and is pressed down lightly upon the slide. The ring of vaseline spreads out and effectively seals the film against evaporation.

Now place a small drop of immersion oil upon the top lens of the dark-field condenser and lay the preparation directly upon it. This oil serves to join the lens to the glass and effectively excludes all air between them. The refractive index of the oil is practically the same as that of the glass so that the light freely passes from condenser to preparation with scarcely a trace of refraction at the various surfaces. For similar reasons, a drop of oil is now placed on the cover-glass and the objective is gently lowered until it also is immersed.

Now will follow a lot of tedious adjustments which need not be described in detail. They will consist in the usual focusing but it will demand manipulations of unbelievable nicety. The condenser must be raised or lowered, or shifted on its axis by the adjusting screws until the bacteria or entomebae are clearly seen to glow against the field of black.

Unexplored regions of photography await the man who has the patience and the interest to use the dark ground condenser. By means of a special condenser of this general type, it is possible to photograph colloidal infusions as before mentioned. The globules of fat in milk, dust particles in suspension, and other similar subjects, must be attempted by this means. However the technique here outlined has not yet sounded the depths of the photographic process for it is a well known principle of photomicrography that the shorter the wave-length of the illuminating source, the finer the detail recorded. Thus by the use of the ultra-violet rays—invisible to the eyes—and the use of special lenses, condensers, slides and cover glasses made of quartz, Barnard, in London, recently photographed the invisible germ which is supposed to produce cancer. The camera had recorded that which the eye may never see.

I promised to refer to the "Super-microscope" before I concluded and I feel that I must do so in order to fully cover my subject. Furthermore, I believe that this instrument offers great possibilities and since it is almost untried, in connection with motion pictures, I shall hope to be the means of stimulating interest in its use.

This instrument, manufactured by F. Davidson & Co., of London, is equally useful for observing the movements of a microscopic diatom or the moons of Jupiter. Yet its principle is most simple. It consists merely of a sub-stage lens of rather long focus which brings the image of the object to a sharp focus at the stage of the microscope. This aerial image is magnified by a compound microscope of the ordinary type and enormous magnifications are thus possible. It might be described as a "Double Compound Microscope" since, as we have already seen, the more familiar "Compound Microscope" magnifies an aerial image in the eye piece. From very strict considerations the "Super-Microscope" might be denied as a new invention since the ordinary compound microscope, with its sub-stage condenser, frequently functions as a "super" microscope. For example, during the manipulations with the microscope, preliminary to photography, it not infrequently happens that the adjustment of the various elements causes an image of the arc lamp to come into view. The ruddy glow of the crater is a familiar sight, with its flying particles of glowing carbon. In fact, it is sometimes difficult to get rid of this amazing phenomenon. Even when the microscope is used visually, it is a familiar experience to see distant trees and clouds in focus simultaneously with the object under observation and it is then necessary to turn the mirror to reflect light from some cloudless portion of the sky.

But, while the principle is not new, the application is a decided contribution and reflects great credit upon the designers. The extreme magnification of the aerial image exaggerates, at the same time, every defect of the lens by which it is made. The optical perfection of the lenses in the Super-microscope is such that a remarkably brilliant image is produced which permits a very high magnification. The lenses come in three focal lengths—one to be used at infinity, one at a distance of 3 feet and one at a distance of 1 foot. Besides being remarkably perfect in their optical qualities, these lenses are mounted in tubes equipped with a series of diaphragms to shut out extraneous light and, all in all, seem to be unusually well made.

But the peculiar virtues of the apparatus have yet to be pointed out. In the first place, there is a remarkable "working distance" which permits insects to be viewed from a distance of several feet, while, at the same time, permitting of full sized images. But the most conspicuous property is the unbelievable depth of field which this instrument permits. It is like no other microscope in existence. The theory involved is probably as follows: the field lens, working from a considerable distance, has the degree of depth normal to its aperture, its focal length and its extension. The aerial image, however, is condensed into a comparatively small plane at the stage of the microscope and this shallow plane of sharpness comes within the limited depth of field of the microscope objective so that the whole of the focal depth of the first lens is transmitted by the second. I do not doubt that other important factors contribute to this effect but this theory has always seemed to me to explain the phenomenon. Certain it is that the visual effect is most striking to one who has been trained to accept the focal limitations of the standard microscope.

The effect gained is exactly that which is to be expected when a small negative of considerable depth is enlarged. The larger print has retained all the depth of the small negative. The instrument has retained all the depth of the small negative. The instrument has advantages however in that the entire enlargement takes place in one operation. But it has a great limitation in that this magnification of the image is secured only with corresponding loss of illumination. It will be extremely difficult to secure sufficient illumination for greatly enlarged photographs from any considerable distance, but within moderate limits, and with a cool source of light, I feel that this instrument should prove to be extremely useful.

Personally, I have never photographed close-ups with the Super-microscope. I improvised one hurriedly on the occasion of a solar eclipse and secured some interesting astronomical film. Furthermore, early in the war, I had an opportunity to use the instrument for direct observation and I look forward to the opportunity of testing this instrument to the full limits of its power.

With a few practical details of a general nature, I shall now conclude this paper. The best microscope for the purpose is one with a large barrel which avoids internal reflections. However, if only the normal visual tube is available, it can be used equally well provided care is exercised. It may be necessary to line the tube with black velvet in case the walls reflect light. For critical work, the length of the draw-tube must be set to correspond with that for which the lenses are corrected. The manufacturer's manual will give this information. In the higher powers a slight mis-setting of the tube length will prevent the lens from operating with the full corrections which are available. It will make an indifferent lens out of a good one. Also, for the same reason, the thickness of the cover glass must correspond with that for which the manufacturer has planned. The objective has been designed to view an object always under a cover glass of definite thickness and this consideration has entered into the calculation for the lens. So again refer to the manual, find the thickness of the cover glass which is recommended and be guided thereby.

It is often stated that apochromatic lenses are absolutely necessary for this microscopic work. They are extremely advantageous but are not vital. Personally, I use the least expensive of lenses, achromats made by a good manufacturer, and I do not believe that my work has suffered for lack of the more expensive ones. Apochromatic lenses are slightly over corrected and are best used with a type of ocular which is termed a compensating ocular because this unit of the apparatus is intentionally under-corrected in order to equalize the correction of the objective. The achromatic objectives are particularly useful in the lower powers or when used without ocular. In the higher powers, the finer corrections of the apochromatic objectives, in combination with compensating oculars, are a decided advantage.

It is well to avoid an ocular of high power. It is better to depend upon a higher power objective and a longer bellows extension, rather than to magnify a small image with a high power ocular. The finest ocular of all is one known as a "projection ocular" designed for projection of microscopic objects for class room demonstration. It is of the compensating type but is equipped with a focussing mount so that the image of the diaphragm may be sharply focussed on the screen. I noted a marked improvement in my results as soon as I secured one and discarded my Huyghenian ocular.

However, there are many occasions when no ocular is needed and I then insert a pasteboard tube in place of the ocular. This is lined with black velvet in order to prevent reflections. The image is thus projected directly through the instrument from the objective to the camera.

It is a tremendous advantage to be able to watch the field of the microscope while the camera is in operation and, for certain purposes, it is a necessity. I was fortunate enough to secure a side view device made by Ernemann. It is far from perfect but has proved most useful. It consists of a cover glass—as thin as paper—set at an angle of 45° in the path of light just in front of the camera. Most of the light passes through this glass without deviation and produces an image in the camera. A small portion, however, is reflected out to one side where it forms a second image on a thin glass screen. This image is magnified by a simple microscope. It is thus possible to see, through this side tube, the action which is being recorded on the screen. However, when the camera is in operation, there is sufficient vibration so that the image is not steady but trembles slightly so that it is never possible to secure a critical focus with this device. It is necessary to focus directly upon the film or ground celluloid at the aperture of the camera and to use the side tube only to keep the object within the field of view. The familiar double oculars—known as "demonstration oculars" by which students and teacher may both view an object—are useful in some cases. However, this device is only available when an ocular is used and, furthermore, such oculars are made on the Huyghenian principle, which is not a good photographic ocular and they furthermore use too much light for the secondary image. Sometimes, I have looked directly upon the film during the progress of the scene by looking through the focusing device. This may be done quite simply with the De Brie camera or the professional Pathé and less readily with the Universal. However, such observation is not entirely satisfactory due to the pronounced flicker of the taking shutter. However, it is an extremely useful method of observation and should be attempted without hesitation by any worker who lacks a viewing device of greater refinement.

One word about vibration. I hope no one may ever be forced again to work with such a flimsy camera as I used during my pioneering days some twelve years ago. The camera itself vibrated and it was necessary to design special cast iron plates to clamp it down. The problem is simplified by modern precision cameras but it must still be kept in mind and the worker must be always on the alert to make certain that his equipment remains firm and does not develop vibration.

Study of authorities in still photomicrography will be extremely useful although the problem of the single large view is quite different from that of the motion picture series of small views. Time is not a consideration in the older type of work and familiar examples call for exposures of many seconds and sometimes of many minutes. There is almost nothing of direct application to the special problem of the motion picture photographer. The short section entitled "Cinematomicrography" which is found in the "Handbook of Photomicrography" by Hind and Randles is too slight to have any value. The book, however, contains a photograph of the Ernemann apparatus and is interesting for that reason. In other ways, however, this book is a splendid work and is full of thoroughly practical instructions for proper manipulation of the microscope. Another standard work is "Practical Photomicrography" by J. E. Barnard and both of these books should be on the shelves of the worker with the microscope. A book of great importance which helps to provide the information which these other books lack is "Optic Projection," by Simon Henry Gage and Henry Phelps Gage. The section dealing with microscopic projection has direct application to the problem of photography and is worth careful study and frequent reference.

More detailed instructions are scarcely possible within the space of this paper. Something must be left to the ingenuity of the individual operator but it is my hope that such instructions as I have outlined may permit others to achieve results a little more readily than is possible when the whole process must be solved by individual experimentation. At least, I hope that these directions will give more explicit information than that which I received when I first went to work. These instructions, translated from a German manual, were approximately as follows: "Secure the camera to the optical bench and take the exposures in the usual manner."

DISCUSSION

Mr. Tuttle: With regard to the alleged advantages of the super-microscope, this is a fallacy which has got into the literature a good many times. The Super-microscope merely magnifies the image from the primary microscope. It gives greater depth of field but has no advantage over a great extension of the bellows of the camera or the use of a very powerful ocular. It shows no detail which the objective of the first microscope cannot see; it merely magnifies, and this could be achieved by moving the projector back from the screen.

With regard to more recent apparatus now available on the market as regards viewing devices and light sources, there are beam splitters made by Leitz and by Zeiss and another called the "Microphot" which are very good for this purpose. They enable one to see the field and photograph at the same time. They are made of prisms silvered and cemented instead of a thin paper slide as in the Ernemann which Mr. Stone describes and which is subject to vibration. With regard to the question of light sources: I think a 30-volt, 30-ampere projection lamp is very difficult to use, and I suggest the 108-watt ribbon filament Mazda or the Tungsarc for the purpose.

Mr. Goldman: The Spencer Lens Company put out a heat absorbing glass which has solved our problems.

Mr. Griffin: With regard to a constant feed single point light source, I don't know how a low intensity arc could be applied, but with very few amperes it can be made constant and maintain its position with any set up. I don't know whether it could be made small enough, and it could not be made in quantities because consumption would not demand it.

Mr. Tuttle: I think that is a valuable suggestion and should be worked out. In connection with light sources Mr. Stone's suggested use of the quartz mercury vapor lamp intended for therapeutic purposes should be commented on. It sounds dangerous and the fact that it is quartz has no advantages. You get no additional photographic radiation through the quartz that is not absorbed by the lenses in the microscope.

Mr. Stone: Give me cold light and a Super-microscope and I will do what is impossible by any other means. The visual depth is inconceivable to one who knows only the regulation microscope. I have used it visually and it is marvelous. I made one once for the photography of an eclipse and it saved me from failure. One man is now actually using the instrument and I am sure that he is pleased. He bought it on my recommendations, and ordinarily I should have followed his progress. However, he was so pleased with the instrument that he straightway announced that it was his invention and I did not trouble to assist him further. But I am convinced that it is the greatest instrument yet devised for popularizing the photography of moderately small objects such as insects. It will need an intense cool light because illumination is low but given such a source of light, or a still subject and moderate light, it will achieve superb results.

The Super-Microscope.—Some notes on the early history of this have been stumbled on that may be interesting: "The tele-microscope.—The following account of Dr. Elmer Gates' alleged experiments in 'tele-micrography' is taken from a contemporary:—It is now nearly a year ago since I first described to several friends the method of applying the objective of a second microscope to the focal plane produced by the objective, or the objective and ocular, of a first microscope, which I had at that time accomplished. I succeeded by this method in resolving the markings of a test object by a sixth-inch objective in the first instrument and no ocular, and a two-third-inch objective in the second, which could not be seen or resolved by a one-sixteenth-inch oil immersion lens and a half-inch ocular, full tube length. I used an additional or supplementary tube, with an objective at its lower end and an ocular at its upper end, and removed the ocular of the first microscope and inserted this tube into the main tube of the first microscope. Later, for convenience, I mounted this tube upon a stand of its own." (Brit. J. Phot. 1897, *44*, Supp. 92).

Another note appears (Brit. J. Phot. 1899, *46*, 20) which is taken from the *American Journal of Microscopy*, which may be the "contemporary" referred to above. As the English makers of the Super-Microscope claim to have a patent on the same, though this has not been found, it would be interesting to know who actually invented this device.

THE DUPLICATION OF MOTION PICTURE NEGATIVES

J. G. Capstaff and M. W. Seymour*

THE making of a first class duplicate negative calls for greater skill and makes greater demands upon the materials than appears at first sight.

A perfect duplicate negative would be one which would give prints identical in every respect with those obtainable from the original. This means that the duplicate negative should have perfect tone reproduction and definition or sharpness and should appear no more grainy than the original. The essential requirements thus placed on the printing material are: sufficient latitude to reproduce correctly the greatest scale of tones likely to be met with in an original negative; extremely high resolving power; and fine grain. To these must be added the practical requirement of sufficient speed for contact printing. It may be said that no one emulsion excels in all of these characteristics. If an emulsion has the finest possible grain it cannot also possess the greatest latitude obtainable combined with the maximum speed, and so on.

Each type of emulsion is made for a particular purpose and consequently has the qualities most essential for that purpose even at the expense of other desirable, but less important, qualities. Motion picture negative film is especially designed for use in the camera. It has high speed to permit taking pictures when the light is not brilliant, great latitude to cover errors in exposure, and a medium value for its maximum contrast. It also has sufficiently high resolving power and fine grain to serve its intended purpose. Although it is an excellent negative material, it is not the best for making duplicates. Positive film, on the other hand, is intended for making prints for projection; it has latitude to cover the range of tones in a normal negative and the speed necessary for contact printing. It also has fine grain, high resolving power, and sufficiently high contrast to give good prints from flat negatives. The best duplicating material, however, should have even higher resolving power and a lower maximum contrast. The reasons for this will now be considered.

A motion picture negative under the microscope is seen to be made up of black silver particles with clear interstices between. Whereas the function of the printing emulsion is to image these

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particles and interstices, no emulsion made has high enough resolving power to do so perfectly. The image of the granular structure always appears more ill-defined and coarse than the original, with the result that the picture when enlarged on the projection screen appears more grainy than the negative from which it was printed. The increase in graininess is not serious in positive prints from original negatives, but unfortunately it can become painfully evident in prints from duplicate negatives, because in the operation of making a master positive, then a negative from this, and finally a positive print, the grain structure is coarsened three times. It is essential then that if the graininess of the screen picture is to be kept at a minimum, the emulsion used in making both the master positive and the duplicate negative should have the highest possible resolving power.

It is desirable that a duplicating emulsion should not have a high maximum contrast, not only because high contrast is unnecessary, but because of development defects that occur when development is not carried to completion, as would be the case were a high contrast emulsion used for duplicating.

The defects produced with low development are termed the "Eberhard" effect and the "Mackie" line. Eberhard, a Danish astronomer, showed that the density of small exposed areas in a film differed from that of large areas which had received the same exposure, and that the inequality was greatest when development was incomplete. He found that under these conditions a small exposed area surrounded by an area of less exposure developed up denser than it should, while small areas surrounded by areas having greater exposure developed up with less density than they should. The explanation of the phenomena is simple. In the first case, the developer acting on the small exposed area diffuses into the surrounding gelatin as it becomes exhausted, and fresh developer diffuses into the spot from all sides thus accelerating development. In the other case, when the small area has had less exposure than its environment, the opposite conditions hold, development of the small area being actually restrained by the reaction products diffusing into it from all sides. If development is stopped at an early stage, the defect is quite pronounced. If, however, development is continued until the image has reached maximum contrast, fresh developer has time to soak into the film from the outside and the irregularity is smoothed out.

The "Mackie" line has a similar explanation to the "Eberhard" effect and is really a manifestation of the latter on a scale that is easily discernible in the projected picture as a sort of halo surrounding the images of dark objects against light toned backgrounds.

It is particularly desirable to avoid these defects in the duplicating process because, like graininess, they are cumulative, and they are largely responsible for the "duped" appearance of prints made from duplicate motion picture negatives prepared on a high contrast emulsion.

Attempts have been made to find a developer or developing conditions that would permit development to a low degree of contrast without producing the defects but with no success. Apparently, the only way to eliminate the fault is to use an emulsion which when nearly fully developed will give the contrast or gamma required.

Inasmuch as motion picture negative and positive films do not completely satisfy the rigorous demands made on a duplicating material, efforts were made to produce something more suitable. It was found that the characteristics of an emulsion are greatly changed if a dye that absorbs the wave-lengths of light to which the emulsion is sensitive is mixed with the gelatin. In the case of an ordinary emulsion certain yellow dyes have this property. The addition of the dye has the effect of increasing the resolving power by reducing irradiation or scatter, greatly extending the latitude, and lowering the maximum contrast of the emulsion. By so "doctoring" a very fine grained emulsion, a film was produced which possessed in a marked degree every desired property with the possible exception of speed. The speed, unfortunately, is rather low, being only about one twentieth that of regular positive film. However, by using a suitable condenser system, sufficient illumination to print from dense negatives at the usual step printer rate can easily be obtained. It is practicable also to do projection printing with condenser illumination.

The dye used is a water soluble yellow that washes out during the processing operations and leaves a normal appearing black and white film. The emulsion keeps extremely well and can be handled in the usual positive safelight.

The use of this film known as "Eastman Duplicating Film," for both master positive and negative insures excellent tone reproduction, freedom from development defects, and a minimum of graininess.

The first step in the actual process of making the duplicate is the timing of the original negative for printing The exposure for each scene should be such as to just clearly record the details in the highlights. The exposure should not be much greater, however, than that necessary to secure the lightest detail; otherwise, the graininess of the final print will be accentuated. After the original has been timed, it should be carefully cleaned to remove all traces of dirt from any scratches that may be present on the gelatin or support. Chamois skin moistened with carbon tetrachloride may be used for the purpose.

If the master positive and duplicate negative are to be printed by contact great care must be taken to insure close and uniform contact of the films at the printing aperture; otherwise the advantages of the high resolution emulsion will be lost. It is obvious enough that poor definition will result if the films are out of contact during printing, but it is not so obvious that lack of uniformity in contact can do any particular harm. If the two films are not in close contact over the whole picture area, a patchy image is produced which on projection resembles uneven development To test a printer for uniformity of contact, a print should be made from a strip of evenly fogged and developed negative film. If the printer is in perfect adjustment, the print will show an even tint, while imperfect adjustment will give the patchiness referred to. The best type of printer has a curved track and pressure plate. The radius of curvature should be small, about $1\frac{1}{2}$ inches, and the pressure plate should be undercut over the picture area so that it presses only on the sides of the film over the perforations.

When projection printing is resorted to for printing either the master positive or the duplicate negative, the lens chosen should be one designed to work at unit magnification. Ordinary camera lenses do not give their best definition under this condition, because they are designed to focus sharply objects at a distance. Clearly, the focusing of the printer lens must be very critical if the sharpness of the original negative is to be attained. It is important to keep the lens clean, since the slightest finger mark or film of dirt on the lens will scatter the light rays and distort the tone reproduction.

For developing both the master positive and the duplicate negative a good form of continuous machine is best. Next to this comes development on a reel. The spacing of the supports on the reel should be close, so that the film will lie in a smooth spiral. Wide spacing of the supports gives uneven development.

If tank development must be used, the rack should be lifted completely out of the developer once every minute so as to prevent rack marks.

The developer recommended is:

	Metric	*Avoirdupois.*
Elon	4 grams	1 lb., 11 ozs.
Sodium sulphite, dry	75 grams	$31\frac{1}{2}$ lbs.
Hydroquinone	1 gram	$6\frac{3}{4}$ ozs.
Sodium carbonate, dry	25 grams	$10\frac{1}{2}$ lbs.
Potassium bromide	1.5 grams	10 ozs.
Water to	1 liter	50 gals.

With unused fresh developer at a temperature of 68° to 70°F, the effective maximum of contrast ought to be attained in about 4 minutes. Development beyond that required to give maximum contrast must not be given or increased graininess will result.

The master positive development, if correct, will give a print somewhat softer than one intended for projection. It will also, of course, differ from the latter in having a slight veiling over the highlights.

The usual acid hardener fixing bath may be used for fixing, although the hardener tends to set the dye and retard its washing out of the film. Sufficient washing should be given to clear the film, since a very little yellow dye will cut down the printing light and make timing more difficult.

If it is desired to make a duplicate negative that can be printed without light changes, the timing of the master positive must, of course, be accurate. By projecting the master positive, one can readily determine which scenes need more or less printing light than the average, and with a little experience the light change required can be estimated quite closely. The "key" light can be ascertained in the usual way by printing and developing a test strip. The scene chosen for the test should be of the most contrasty subject; that is, the scene with the darkest shadows, and the printing exposure should be just sufficient to give a veiling over the deepest shadows. If this precaution be taken, all of the other scenes will automatically be taken care of, and the tone reproduction of the entire length will be satisfactory.

In order to learn if the duplicate negative will require a longer or shorter development than that given to the master positive, superimpose one of the scenes in the master positive on the corresponding scene in the original negative. If the registered positive and negative images exactly obliterate each other, then the duplicate negative should be given the same development as the master positive received. A faint residual negative indicates that a somewhat longer development must be given to the duplicate negative; if, on the other hand, a faint positive image be seen, the negative should be developed for a shorter time than that given to the master positive.

If the various steps in the preparation of the duplicate negative are carried out correctly, it will stand the test of direct comparison with the original under a low power magnifier. Examination under a higher power lens, however, will probably show some loss in definition and an appreciable increase in graininess. The definition loss arises, for the greater part, from poor contact in the printer. Too much emphasis cannot be laid on the necessity for intimate and uniform adjustment at the printing aperture.

Some increase in graininess over the original negative appears to be inevitable, but that obtainable on the Eastman Duplicating emulsion is, as has been stated, considerably less than is given by any of the regular emulsions. To keep the graininess of the final prints at a minimum, the prints should be kept as soft as is consistent with good projection quality.

In the foregoing procedure it has been assumed that any modifications required in contrast would be secured in the usual way by slightly varying the amount of development. The Eastman Duplicating Film, however, has a unique property not mentioned hitherto which can be made use of in practical work. The contrast or gamma of the image can be varied within wide limits merely by altering the color of the printing light; in other words, a contrasty, medium, or soft master positive can be made at will with the same amount of development. A yellow filter placed between the printing light and the film will give a high contrast image, white light will give a medium contrast, while a deep violet filter will give a low contrast. By taking advantage of this fact it becomes quite practicable to print onto the same length of film from contrasty and soft negatives and to compensate for the variation in negative quality by printing through suitable filters. In practice it is found that three violet filters of different dye densities will give the range of control necessary on average commercial work.

A precaution not to be overlooked is that the printing light should always be run at a standard voltage because of the color change that occurs with voltage changes. If the brightness of the printing light is changed by a rheostat from scene to scene, the scenes printed at low voltage will tend to be of higher contrast than those printed at high voltage. This is true whether or not filters are used. It is advisable to run the lamp at constant voltage and to use the diaphragm method of changing brightness.

In conclusion, it may also be pointed out that the highest grade of work on the new emulsion is produced when advantage is taken of its contrast control property because this permits of complete development for every scene with the consequent avoidance of all development irregularities.

DISCUSSION

Mr. Gregory: Is this film for sale?

Dr. Mees: Yes, it has been for a number of years, but there have been no instructions for its use. We are going to issue a booklet on the subject.

WHY SLIDE FILM?

Rowland Rogers.*

1. *What is slide film?*

Some wise "gent" once said: "There's nothing new under the sun." In stating this truth, he was a great liar. Now, slide film *is* new,—except for the fact that the idea is very old.

Slide film is the grandchild of the magic lantern. The magic lantern had a child. Its name is stereopticon. You know it well.

As Granddad Magic Lantern and the Son Stereopticon used a screen on which the images were projected, so does the Granddaughter Slide Film. The better the screen, the better the projected picture. Any good stereopticon screen will do for the slide film. Of course, a reflecting screen for a narrow room and a diffusing screen for a wide one.

There are several standard slide film projectors in use. All make use of the electric lamp as a light source for projection.

The main point of difference between slide film and the stereopticon is this: the stereopticon uses glass slides to hold the photographic image. These slides are ordinarily about three or four inches long. Each is detached or separate from the others. Slide film, on the other hand, makes use of regular motion picture positive film. Each frame of the slide film picture is a movie frame. The image in the frame is $\frac{3}{4}$ of an inch high by 1 inch wide. Each picture is attached to its preceding and following neighbor. With the slide film one picture follows the other in fixed succession. Each frame is projected separately, but in fixed, continuous order. A correct term to describe slide film would be "still film" as distinguished from "movie film." There is no attempt to give the similitude of motion. One still picture follows another in the sequence of projection without a break or interruption. Each picture may be held on the screen as long as desired. There is no defined rate at which they must be projected. The rate is left to the discretion of the projectionist. He in turn is controlled by the needs of the audience. In other words there is no standard projection speed because none is necessary.

* Picture Service Corp., New York, N. Y.

2. *What are the advantages of slide film?*

During the three years just passed the use of slide film has grown from nothing to proportions deserving attention. The idea has received a favorable acceptance. The use is still limited when compared to the possibilities of use in the field.

What are the advantages? I shall list each in order, then follow with a brief comment.

A. Low Cost;
B. Satisfactory Projection;
C. Ease and Simplicity of Operation;
D. Lightness, Compactness and Portability of Projector and Film;
E. Freedom from Breakage of the Film. Durability.

A. *Cost.* The low cost of slide film prints has been an important factor for success. After a negative is made, slide film prints can be made almost as cheaply as regular motion picture positives. Assume that the average slide film is about 80 frames long or roughly 5 feet. In general, the customers price for this specially made strip will range from $4.00 for single orders to $2.00 in quantities of twenty or more ordered at one time. The selling price of prints from a film library where the negative cost has been amortized range from 50c to $3.00. In other words the customer receives a set of 80 frames, the equivalent of a set of 80 lantern slides for $2.00. An average price on lantern slides is 50c a piece. Eighty slides ordinarily would cost about $40.00.

B. *Illumination.* For many uses, and probably most, the screen illumination is adequate. This is especially true where the throw is short or at distances from 10 to 40 or 50 feet. A satisfactory picture may be projected in a darkened or partially lighted room.

C. *Simplicity.* Neither technical knowledge nor a high degree of skill is necessary to operate slide film projectors. Most operate either by pressing down a lever with the thumb or turning a round handle or button. This causes the picture next in order to appear. Some of the machines may be turned backward one or more frames to repeat the showing of a scene where desirable. Usually the film is wound on a reel about the size of a large size spool or in some instances wound on itself without the use of a reel. The free end after being fed through the aperture is rewound on a take-up spool or runs free. The operator rewinds by hand around his finger.

D. *Portability.* A complete outfit with a carrying case holding a dozen rolls of film weighs 5 to 6 pounds. The projector and film may be placed in a brief case or in a projector case especially built for carrying purposes.

The projector is attached to the ordinary lamp socket. The whole operation of attaching to the socket and starting the picture can be performed in less than 50 seconds.

E. *Durability.* Especially when the film is wound on spools, the life of each print is long. If the film is dropped it does not break as does the ordinary lantern slide. Even with rough handling a print may be projected from fifty to one hundred times, or more.

3. *What are its limitations?*

1. The amount of light which may be projected through the aperture is limited by the size of the film frame, $\frac{3}{4}$ of an inch by one inch. Because standard movie film comes in this size, we find here one of the inherent limitations in the use of slide film.

By comparison, a stereopticon has an effective light opening several times as large, so the stereopticon admits and throws more light, and, of course, has greater screen illumination and may have a longer effective throw.

Each frame must remain in front of the light as long as the operator desires. There must be no burning, warping nor excessive drying out of the film. In other words the amount of heat which reaches the film must be reduced to a minimum. Of course, due to the fact that cellulose acetate or "non-flam" film is used, there is no fire hazard. Still, an excessive amount of heat would ruin the film by causing warping or drying out. The size of this aperture thus reduces the amount of available light. So the amount of illumination on the screen or screen brilliancy is definitely limited, since we have not developed a light source without heat. Depending upon the suitability of the heat resisting method and the optical system, more or less heat may reach the film. For practical purposes in the better designed projectors, heat does little or no damage. The tendency to buckle has been greatly reduced; but the amount of light coming through the aperture has the definite limitation.

The ordinary portable hand slide film projector uses the usual house current of 110 volts. The light is supplied by a lamp usually burning 100 or 200 watts. One make of projector uses the smaller automobile light of less amperages and with a low wattage.

2. In using lantern slides there are usually a number of key pictures, each of which is supplemented by others according to the lecturer's notion of the need of the audience. Each audience may differ in temperament and intelligence. The length of the lecture may be varied. The number of slides shown may be decreased or increased or the order of showing changed.

Still film lacks this flexibility. The frames of the slide film come in a regular or fixed order. Experience shows that if the subject matter is carefully thought out and the series of key pictures chosen, with such fundamental supplements as the lecturer thinks necessary, this lack of flexibility becomes more apparent than real. The other advantages of the slide film overcome to a large extent this rigidity of permanent sequence.

4. *How is it projected?*

All slide film projectors which have come to my attention operate upon the same principle. That is, they use an electric lamp as a light source. The light is thrown through an aperture which contains a frame of the slide picture. In front of the slide film is a lens adjusted to fit the requirements.

Most slide film projectors operate from the 110 volt ordinary house-light circuit. As already stated, they use either a 100 watt or a 200 watt nitrogen lamp most frequently. Some of the projectors are equipped with automobile lamps and may be operated from a generator on a motor car or from a 30 volt circuit. Suitable resistance is provided somewhere, sometimes in the cord.

So far, I have been speaking exclusively of the manually operated projector. Developments within the past year have worked out a continuous projector. This device is especially adapted for showings in booths at exhibitions, in show windows and similar places.

One of the machines is equipped with a push-button device which gives a remote control and throws the next picture in sequence.

The machines frequently used in the east are the Brayco, the Spencer Lens, the Bausch & Lomb, and the Wyco.

Believing you may be interested, I have brought several machines as exhibits, and will show you a film projected. (Demonstration followed.)

5. *How is it made?*

The procedure followed in making slide film depends on the use to which the slide film will be put. In general, the following is standard for films for industrial and sales uses.

A. Determination of the use to which the film will be put. Who will see it? What effect should it have upon them?

B. With this definite objective in mind, a plan and specification (scenario) is prepared. This plan lists the different scenes, develops the order in which they shall appear and the cumulative influence they shall have. It also gives the titles and carefully works out the wording of each in detail. Titles serve as a liaison between scenes, and supplement the picture presentation.

C. Next comes photography. Many of the better grades of slide films are made from still pictures photographed with a still camera. Usually 8×10 stills are used. Each scene is separately photographed; 5×7 stills can be used. However, especially where charts are used, these may be photographed directly on the motion picture negative. Sometimes a still enlargement of the frame of a motion picture negative is used. Where actors and props are used, in addition to the still cameraman, a director is placed in charge of the work of making the stills.

With the scenes assembled in the form of still pictures and titles, the motion picture photography starts.

A most practical device for making slide film is the motion picture animation camera which uses a stationary stand. The camera looks down upon the picture or title. With mathematical accuracy, the pictures and titles are placed in position. The camera photographs in sequence one frame at a time. Each frame contains a different title or picture. Great care must be exercised, that the sequence of scenes and titles as it appears on the negative is not spoiled or broken. Patches in the negative are not desirable, and at times are impossible.

The exposed negative is developed in the same manner as regular motion picture negative. Prints are made in the same way.

Although a slide film may be from one frame to a thousand or more long, a practical or average length of a print is 80 frames or about 5 feet.

6. *What are its uses?*

A glimpse at the catalogue of slide film shows three fields where it has made a substantial development.

These are: (1) Education; (2) Religion; (3) Industry and Commerce.

In the educational and religious fields, slide film usually consists of a series of titles and descriptive scenes. Anything which may be photographed may be put on the film, and we find reproductions of famous paintings, scenes in the holy land, maps, charts, and so on.

The religious films are based on famous masterpieces such as those of Doré, Rubens, Da Vinci and so forth. There is a series on the life and travels of Christ and one on the Bible and its stories.

Films have already been produced on the following educational subjects: Agriculture, Biology, Civics, Social and Public Service, Geography, History, Home Economics, Industrial Processes, Literature, Nature Study, Health and Hygiene, and so on.

In the field of Commerce and Industry, the slide film projector is used for missionary and sales promotion work and for sales instruction as well as public relations. Salesmen may be instructed by the home office by regular sales bulletins in film form. They may be equipped with projectors to demonstrate to the dealer the standing of their company or the merit of their product. Groups of customers may be reached either by the salesman equipped with a projector or by a continuous projector, operated as an exhibit.

The future. There seems no doubt that still or slide film is a genuine utility. Where movement or action is not essential the slide film presents the identical titles and scenes as the "movie." Where, however, action or movement is essential to the presentation of an idea, as is frequently the case, the "movie" is unrivalled.

Slide film fills a useful niche in visual presentation. It should have a steady growth and continue to serve such useful purposes as

1. Cutting the time of explanation;
2. Increasing the effectiveness of presentation by making a clearer, more vivid and lasting impression;
3. Cutting the cost of imparting information.

DISCUSSION

Mr. Goldman: Are there any special printing devices for these negatives? Each one is lighted differently. Is the ordinary printing machine used?

Mr. Rogers: As far as I know, no special devices have been developed. The films are sent to a good laboratory and they work out the difficulties. It may be that something has been worked out but it has not come to my attention.

Mr. Porter: It seems to me that there is some demand in connection with these types of projectors for a camera with which a man can make single slides. Are there any cameras on the market that can be used for the purpose?

Mr. Rogers: Any motion picture camera with a single framing device can be used. One of the producers has adopted a Sept camera which can make motion pictures or still pictures, but I believe it has not met with any great measure of success because in the hands of the amateur you are apt to bungle a frame, which gives a patch in the negative. On the other hand, with interiors with a 2-inch lens you require a good deal of artificial illumination and a tripod, so that the practical way has been to make stills and then photograph on the motion picture negative.

Mr. Porter: Motion picture cameras are relatively expensive, and I should think there would be a good field for a camera of this kind developed at low expense; it would be valuable in the entertainment field.

Dr. Hickman: There is such a camera on the market; it is the Leitz-Ica camera. It has a 3.5 lens, focal plane shutter, and is as small as one of the folding Kodaks. It takes single frame pictures on 35 mm. film by one pressure of the button.

Prof. Wall: I had one of the Leica cameras in Bermuda. The size of the picture is two frames, $1 \times 1\frac{1}{2}$ inch. You can expose thirty-six pictures in one roll. Its only disadvantage is that you must go into a dark room to load it. There is another box-form camera made by Ernemann about $3 \times 2 \times 2\frac{1}{2}$ inch, taking standard motion picture film and giving one frame exposures.

Mr. Gregory: By means of the trick crank these strip pictures can be made with any motion picture camera and the camera can be used for copying from stills and making positives direct from amateur negatives. The Sept camera I have used with a great deal of pleasure. It holds a little more than fifteen feet of film, and some two hundred and fifty single exposures can be made on it. There is the objection of bad pictures in the sequence, but the camera is very well adapted for copying from stills or making direct positives from the negative. The Sept camera is, I believe, the cheapest and best sort of camera that is easily obtainable for making pictures of this character. The two mentioned by Mr. Cook are no longer on the market. The Ica camera could have a different aperture plate put in it, but without a reduction apparatus the double frame would preclude its use for the ordinary amateur.

Mr. Goldman: How are color inserts added to the film and does each one have to be inserted separately?

Mr. Rogers: Frequently, as you saw in one of the first pictures, they are hand colored. Color photography can be used but it is unwise to insert one frame at a time.

I think we should have in mind the limitation of any of the cameras which we have mentioned. It is not practical to photograph on the negative in exactly the required sequence. If you take only one frame, you cannot patch it in. If you take more, you have a lot of patches in the negative, and the practical way is to use the still picture and photograph in sequence in order to get a satisfactory result.

Small Cameras Taking Standard Cine Film.—It may be of interest to record that the Ansco Photoproducts Inc., Binghamton, N. Y., have placed on the market a "Memo" camera, measuring approximately 2×2×4 inches. This takes enough standard cine film, daylight loading, for 50 exposures; it has an F 6.3 lens with shutter working at 1/25, 1/50 and 1/100 second, and direct view-finder. Change of film is effected by a lever at the back, and the number of exposures are recorded on a dial on the front of the camera. E. Krauss, 18 Rue de Naples, Paris and Etablissement Mollier, 67 Rue des Archives, Paris also issue cameras for 50 or 100 exposures. Ernemann-Werke, American agents Herbert & Huesgen, New York City, offer three forms with lenses working at F 12.5, F 6.3 and F 2. Seischab & Co., Nürnberg P, Germany make the "Esco" camera for 400 exposures.

IMBIBITION COLORING OF MOTION PICTURE FILMS.

William V. D. Kelley.*

ABOUT eight years ago Mr. Max Handschiegl began the coloring of motion picture films by a system generally known by the term 'imbibition.' Mr. Handschiegl's previous experience had been in the engraving business in St. Louis and other places and he sought to apply the knowledge gained in that field to the coloring of films. In a broad sense he has utilized the printing press method of inking from a matrix or similar surface.

Imbibition merely means the transfer of a dye from one surface or body to another. He uses a color plate, corresponding to the engravers' cut or block, which is in gelatine on a celluloid base and which may be a smooth surface with dye selective areas or a matrix with raised portions.

Probably the best known of his early work was in the De Mille picture "Joan, the Woman." The procedure in such an example is for the producer to supply a positive print. From this original print, by various means, which involve printing, etching, or hand blocking, a photographic registering print is made that contains only the sections of the picture that are to be colored. If more than one color is to be transferred, then a separate plate is made for each of the colors. Fire scenes are made as a rule with a single color but the majority of the films colored by this process are done with three colors. A knowledge of the blending of three colors and the engravers' experience with the three-color printing inks is of great value.

This system of coloring is used exclusively for productions already completed. After a production has been cut and edited, the scenes that are to be colored should be joined into one reel, a positive print made with the same perforations as the negative, which also should be printed on a registering printer, and from this print the "color plate" is generated. Once the color plate is made in this manner, the prints for distribution may be made with different perforations, as the coloring machines can register independently of the perforations.

The preparation of the 'color plate' is the result of hand operations. This takes time and careful work as each frame in the reel must be gone over by hand. There is no room for careless work. The

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final result can be only as accurate as the hand blocking-out. These blocked-out prints are known as 'key plates' and once made will continue in service till the subject is worn out. As an example, some prints were made during September this year for which the 'key plates' and 'color plates' were made 5 years ago. The 'color plates' can be used until worn out or ruined by some accident. There does not seem to be any limit to the number of prints that can be pulled.

Some of the better known productions that have used this system of coloring are: "Joan, the Woman," "The Red Light," "Greed," "Irene," "The Volcano," "The Flaming Forest," "Phantom of the Opera," "The Merry Widow," "The Big Parade," "Sally," "Seven Keys to Baldpate," "The Viennese Medley," "The Splendid Road," "Mike," "Lights of Old Broadway."

As a result of working for many years with the subtractive form of natural color photography it was decided that this purely chemical process is incapable of giving satisfactory results under all conditions imposed in practice. Accordingly the idea sprouted forth that if a black and white record made in silver could be used as the base for a color picture that the tints could be applied by mechanical means. This would have the advantage that the 'drawing,' so requisite in all photography would always be assured. In other words, first obtain a good photograph with all the quality possible as is found in good cinema work and as required in present day pictures, and to this picture add the colors.

This has been accomplished and examples will be shown.

The negatives are made in an unusual manner, but any type of color selection negatives will answer. At present the two-color system is utilized, although three or four colors may be used if desired and a camera is used that will give satisfactory negative results.

At any rate the camera used for the examples to be shown makes two records at each exposure, one of which, the red filter record is used to first print on single coated positive stock and form the grey projection print. The positive stock of any manufacturer can be used for the reason that nothing more is required of this film than a good black and white print to which, later, the colors are added.

In all natural color prints that have reached the screen, prior to the present system, and excluding the additive systems, some chemical means of altering the silver salts to colored compounds have been employed. With such methods it is notoriously difficult to maintain uniform results.

In the present system, the method of coloring is similar to lithography. The result is a pure, grainless color or colors applied to the grey projection print. The idea, broadly, is old, for we have the same methods in the quadricolor press prints seen on magazines, calendars, and illustrations of all sorts. The printers found they needed the black or grey key print to add life and snap to their work.

Another important point from the commercial angle is that we are able to give a constant color to the prints. We can keep the color low or high but whichever is chosen the colors will be the same always. Not quite so when toning with dyes. In toning all sorts of changes occur to upset the balance of the colors or the depth of dye absorbed or washed out. These are facts that could be enlarged upon indefinitely.

So far in the discussion we have covered the negatives and making of positive prints. Now as to the making of the color plates, from which the color is transferred to the prints. In lithography, stones are used which repel greasy ink when wet. In the present system, the plates have the same quality, the gelatine repelling the colors in certain sections and having an affinity for them in other sections. Where the color runs into the gelatine, it will likewise transfer the color. As the plates need only to be made once, or at most four times to care for large orders, great pains can be taken in their manufacture, even to the making of corrections, for once made they can be used over and over again. This is the same procedure followed by the lithographer. As film orders seldom run over 350 copies, these plates will do their work to the end.

The presses that perform the work of printing long and continuous lengths of film uniformly and evenly, and maintaining the accurate register required for modern film productions, form the backbone of this most unusual process. Many years have been spent upon their construction and operation by Mr. Handschiegl, although never before have the machines been utilized for natural color work. Many machines have been made, alterations and improvements added until we reached the highly sensitive and successful machines now employed.

The finished film, in full color, is single coated. The single coating containing a black and white record, a blue-green record and a red-orange record. The film is handled and joined exactly as the ordinary positives known to every one in the film industry. The machinery having been constructed for three-color work it is intended that future work will be in that direction.

DISCUSSION

Mr. Crabtree: In the original process of Handschiegl how long does it take to block out the positive, and how long to put a thousand feet through the dyeing machine?

Mr. Kelley: I haven't been out there long enough to say how long it takes to make the original plates, but I am told it takes many months because the girls and Mr. Handschiegl have to block out every individual frame. As to the speed of production after the plates are made, each machine will turn out ten thousand feet a day.

Mr. Norling: In blocking out, do you use a pantograph?

Mr. Kelley: No. Some of it is done by etching even with a scalpel. A pantograph has never been used.

Mr. John G. Jones: Are you at liberty to tell what method is used in keeping the perforations in register?

Mr. Kelley: The quickest way to find that out is to get Mr. Handschiegl's patents on the machines. The large wheels in the picture have teeth similar to those in a projection machine. The color plate carrying the dye is stretched—it has shrunken considerably—on to the large wheel. The positives are fairly fresh and are stretched also to match the plates underneath. That provides for the up and down register. In addition, the micrometer wheels spring the film in and out so as to obtain side register. In doing outsiders' black and white work, we have to contend with all kinds of perforations—sometimes Eastman and sometimes Bell & Howell.

Mr. Powrie: Do they print the image on with ink and then stain the gelatin or do they print from the positive?

Mr. Kelley: Are you talking about the original Handschiegl process?

Mr. Powrie: Yes, the coloring from engraved plates. They usually print with a greasy ink made from precipitated lakes of dyes on printing paper, but instead of printing in this way I presume they print with a greasy ink using a negative and then stain the gelatin with a solution of dye. Is that correct?

Mr. Kelley: No, it is purely photographic, very similar to Kodachrome.

Prof. Wall: In the micrometer registration is the register on the actual image?

Mr. Kelley: It is on the original image; that is one weakness in it. We must find some different way of registering. It is still very crude.

A DAYLIGHT OPTICAL REDUCTION PRINTER.

O. B. Depue.*

THERE are three methods of printing motion pictures, namely, the step-by-step method, the continuous method, and the optical method by means of a printer which employs a lens to carry the image of the negative to the positive either reduced, enlarged or of the same size. This article describes an optical printer, for the reduction of standard size negatives to 16 mm. positives, Fig. 1.

A striking feature of the optical printer is the fact that it is a daylight machine, that is, it can be operated in a white lighted room and only the magazine holding the positive film need be loaded in the dark room. The great advantage of a daylight printer is the fact that it can be so easily watched in operation. Operators at once appreciate this feature of the machine as it enables them to work with greater ease and safety, so far as handling the negative is concerned, by having a sufficiently lighted room for checking up and handling of the negative and also for preparing the light control for a long run print. The operator can see just what is passing through the printing machine and also by glancing at the open face light control board can see just what light is actually being used in printing the particular scene that is going through the machine at the time.

It is unfortunate that there has not been previously established a standard of timing for various printing machines. This applies more especially to the notching of the negative. For instance, in the Duplex system the notch is placed four frames away from the light change, while in the Bell & Howell system the notch is placed six frames away, and there are some printers that have the light changes eight frames away from the scene change. Now it is obviously impossible to use these various notchings on different systems of printing unless there is some means in the printing machine that will permit adjustment of the machine to fit these varying conditions.

The daylight optical printer has been designed with this in view and we have so arranged the interrupter device that it can be adjusted very easily to fit either a four frame notch, a six frame notch, and even an eight frame notch. Thus a negative that has been prepared for either a Duplex or a Bell & Howell printing machine can be

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handled on this daylight optical printer so far as the notchings are concerned but there still remains for consideration the number of light changes employed by these two different systems. We have arranged our resistance divisions so that by merely moving a lever up or down, we can instantly change the entire system. The resistance contacts are shifted by the operation so that if it is an eighteen light that is wanted, only the first eighteen numbers on the small sliding bar are used. The remaining numbers are in reserve and when the lever is shifted to the other position, the twenty-two contact points

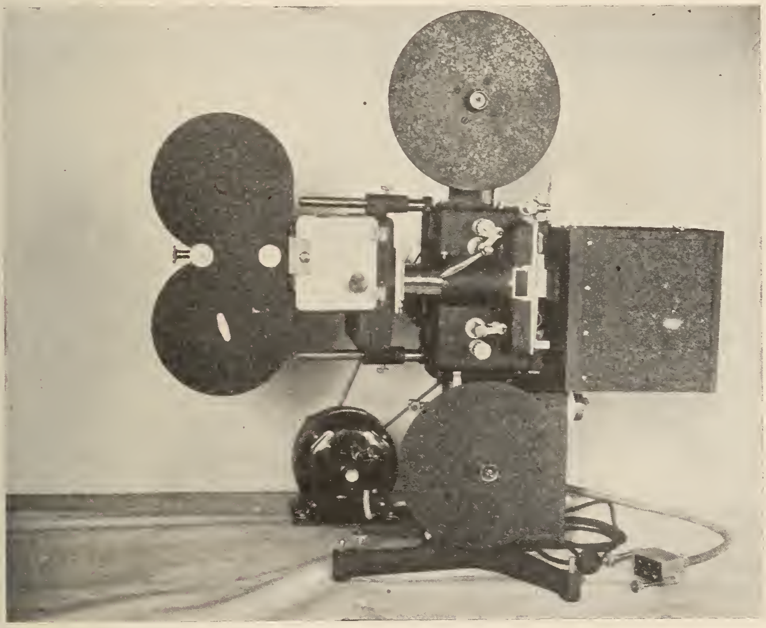

FIG. 1. The Depue Optical Reduction Printer.

are engaged so that the Bell & Howell system of light changes may be used although the negative may have been notched for the Duplex. We consider this a very essential point in printing for the laboratories using reduction printers especially, as in all probability negatives will be offered for printing that have been handled by other laboratories, or perhaps prepared for the two different systems in their own laboratory. It is unnecessary to go to the time and expense of changing the negative for printing on the optical printer when by merely loosening one screw and shifting the interrupter, or by shifting a lever to another position, the work can be accomplished which would otherwise require hours of time by an expert negative girl in rewriting the timing strips and possibly having to take out several frames of a scene in order to bring the notch in the correct place for the printing machine. It also shortens the negative by so doing, and another disadvantage is the fact that should a standard print be required from this negative the work would have to be done over, still further shortening the negative.

Many improvements have been made in printing machines in the last ten years, and there is still much to be desired. The automatic light change has been a step in the right direction, and in this connection perhaps it would be interesting to go back to a few years and describe the first system the writer used in motion picture printing.

In 1897 the writer purchased a Gaumont camera in Paris. The size of the film at that time was 60 mm. in width and 100 feet in length. After purchasing the camera, it was found that it was not so easy to purchase a printing machine or a projecting machine and it was necessary to proceed to build both of them, in addition to a perforator. In order to gain information how to proceed in the construction of a printing machine, the writer visited the Eastman Kodak plant and had an interview with Mr. George Eastman who very kindly gave all the information he had available at that time. He suggested that a machine be built that would pull the negative and positive by means of a sprocket wheel and at an even speed past a narrow slot which would admit the light from a Welsbach lamp which was to be placed in a separate room and on a sliding track controlled by the operator, so that the lamp could be slid back and forth to vary the light strength according to the density of the negative. This method was used for some years, but in place of the Welsbach lamp the electric bulb became available and it was handled very much in the same way. It remained for the Bell & Howell Company to provide a means by which the operator would have a signal, indicating just when a light change was about to take place. This was accomplished by placing a small notch in the margin of the film. This notch closed an electric circuit which operated a bell or buzzer to signal the operator. Later, this same device was used to operate an opening shutter which admitted more or less light according to a scale which was manually operated. This method is employed today by many of the leading laboratories.

The automatic light control used on the daylight optical printer, Fig. 2, works in connection with this interrupter device and when the circuit is closed the magnet operating the change mechanism acts practically instantaneously in making the change, that is, on the first impulse of the magnet the complete light change is accomplished, and the second impulse or return of the pawl on the ratchet has no effect on the actual changing of the light intensity.

In this connection it might be well to take up the subject of arcing of the contacts in making the light change. Such a thing cannot occur with the light control under consideration due to the construction being such that at no time is the circuit broken and there is no chance to draw an arc which would cause heat and corrosion. This is accomplished by so arranging the contact springs that one light bar is connected to the next one before either spring leaves its contact and, therefore, there is no broken circuit and no arcing or heating even when employing a 250 watt lamp, as is used in the daylight optical printer. This rather low wattage for this kind of work is made possible by using 2¼ inch condensing lenses which are placed very near to the negative to minimize the loss of light. On the other hand, a very great gain in intensity is accomplished. These two condensers have their flat surfaces ground by fine emery powder so that they present a ground glass effect, and by adding a small disc of glass ground on both sides in the same way the proper amount of diffusion is secured to give a perfectly illuminated field. At the same time enough light is allowed to pass so that the lens may be diaphragmed down to an eight stop in normal printing, thus allowing considerable latitude for extreme conditions by either opening up wide or closing the opening to a smaller stop.

Another feature that is destined to become popular in connection with the daylight optical printer is that it can be used for enlarging from a 16 mm. positive to a standard size negative with very little changing. A bracket is attached to the reduction end of the printer and the lamp house is merely swung around in position so that the light rays pass through a prism and the small image is thrown onto the negative raw stock which is placed in the 35 mm. head. Of course, this operation requires a dark room. To provide for easy transporting of the machine the pedestal is equipped with ball bearing, rubber-tired casters, and the light control board is similarly equipped. There is a connecting plug which is pulled out from the board, thus separating the machine and the board instantly, and the machines can be

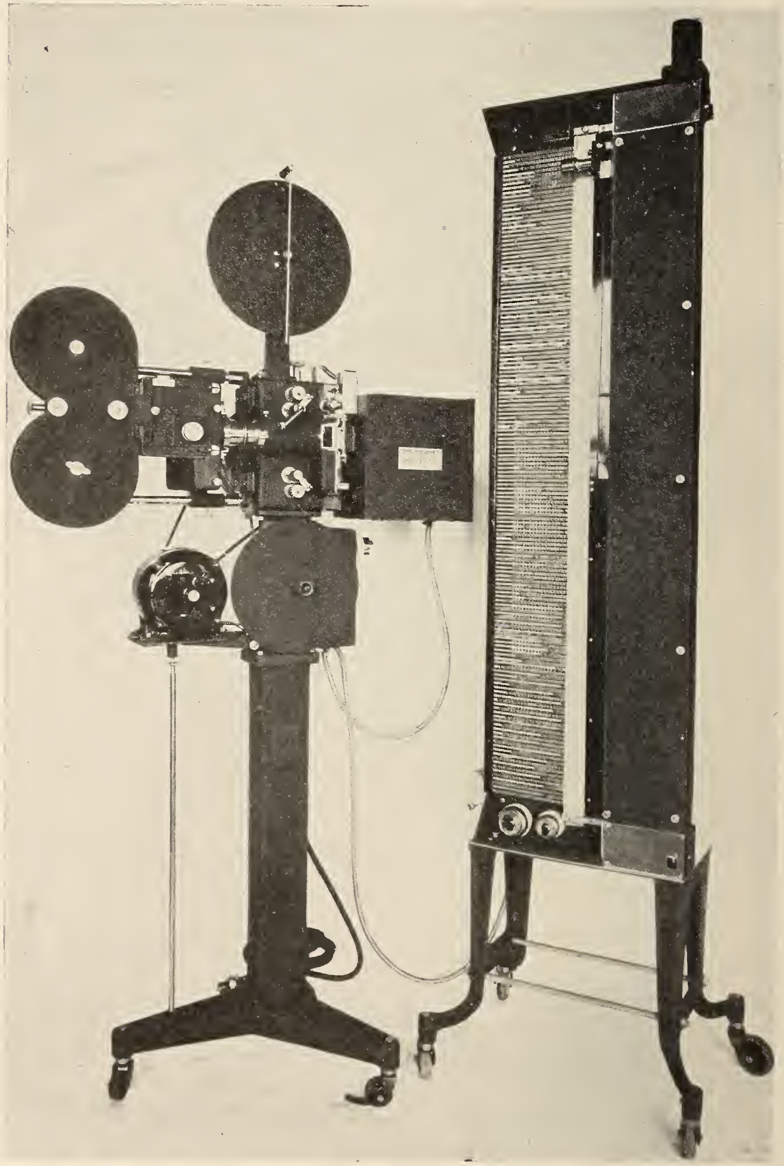

FIG. 2. The Depue Printer Light Control, working in conjunction with the Optical Printer.

wheeled into the dark room with the greatest ease. This connecting plug is so arranged that it cannot be inserted incorrectly and there is no danger of mixing the circuits. This enlarging operation is just the reverse of reducing, and is done at the same speed and with the same lens opening as used in reducing. It may be necessary to use rather a strong light, either 10 or 12 light strength, but otherwise there is no change necessary. This feature of the machine is certain to become popular as there are sure to be some very valuable pictures made with the 16 mm. cameras in the future. Already this feature has been employed in a commercial way. There are many industrial pictures in circulation from which reprints are being made constantly, and there are additions that will naturally be made to these negatives; and the 16 mm. camera has such a great advantage over the standard size that builders of different pieces of mechanism, such as tractors, farm implements and road building machinery, have already taken new machines in operation and they wish this to be included in their standard size negative. Naturally, there is only one way in which to do this, and that is to enlarge, insert this enlargement in the original negative, and then either reduce the complete picture or print it standard size as required.

If the original positive has been carefully made and has good quality, an enlargement is very satisfactory and there is no reason why it should not be used in a greater field than as a single positive picture.

Optical printing of standard size pictures to standard size is also a feature that probably will be employed more and more in the future by producing companies, and the daylight optical printer is capable of handling this kind of work by employing merely a standard size positive mechanism in place of the 16 mm. The machine then becomes quite a different instrument and reduction prints can be printed on this standard size film for effect work in titles or miniature printing or enlarging to several times the size of the original, that is, close-ups can be made where originally taken as a long shot. Double exposures can be made in different sizes of the same subject. In fact, it opens up a new field for printing and producing, and it is impossible to enumerate the many different ways in which an optical printer of this character can be employed.

Perhaps the one feature of this daylight optical printer that will appeal to the laboratory man most strongly is that it can be used as a splicing machine; that is to say, the machine can be used in such a manner that splicing will be unnecessary in the finished print. A brief description of its construction may be in order.

The starting and stopping mechanism is so arranged that when thrown out of gear the machine always stops in a certain position, that is, on the down stroke while the two pins which actuate the negative are still in the perforations but at the bottom of the stroke and the shutter is closed in front of the positive film. Therefore, when a reel is to be printed, composed of several rolls of film, it is unnecessary to make any changes in the negative. The operator needs merely to stop the machine a picture frame or two before the end. When inserting the next roll the first frame of the picture is placed in the aperture and the perforations are placed over the two pins, which are still in position. On starting, the machine picks up the first frame and there is no black space or blank scene in the operation. This is a very valuable asset of the machine as it is highly important in projection that there be as few splices as possible.

The timing strip used on the control board is made film width and is easily filed away with the negative, thus simplifying the printing operation.

DISCUSSION.

Pres. Cook: If the card is only the width of the film, would it be possible to list the titles so that the operator could check whether the light changes were those belonging to that scene? In reduction printers it is very important to identify a particular scene and find if the light box has failed to function.

Mr. Chanier: I think there is a space on the cardboard for identification.

Pres. Cook: Apparently this strip (indicating) is the only space, and it seems inadequate. It is frequently necessary to employ as many as five words so that the printer will be able to identify the scene he is working on. It is obvious that the printer must be seated on this side of the machine (indicating) and the position of the stand carrying a light card would be difficult to arrange so that the inspection could be changed rapidly from the film running in the aperture to the light card and thus assure proper registration. The use of this in the daylight would introduce the complication that pupillary contraction would make it increasingly difficult for him to inspect the image at the aperture, which is the point of constant vigilance to the operator. If a particle of dust lodges it must be quickly observed at the aperture in order to prevent a certain amount of pull-back to reprint the part in defect. It is always desirable to discover any lack of correct functioning and quickly correct it. The great difference between the contact printer and the reduction printer in its output is due to the larger number of things that may go wrong in a reduction printer compared with a contact printer. There are a number of additional parts, any one of which may produce a defect in the product, causing the necessity for reprints. The percentage of waste is not less than 25 per cent, according to Mr. Hubbard, and he is connected with a laboratory having a considerable experience with printing. It is not only the waste of stock but the much greater loss of time in getting out the negative, matching it, and making reprints extending perhaps 2 to 5 feet. It is as much trouble to reprint and insert two or three scenes as it is to do an entire reel. At present one of the greatest drawbacks in reduction printing is the uncertainty in mortality of the production due to the greater complication in the mechanism. Anything we can do to reduce this will increase the efficiency and economy and will play a very important part in the industry.

Mr. Depue: It is very easy to carry out any system of numbering on this paper strip which is divided into three sections. On the left hand side of the paper strip is the place where the light control number is placed; then the wide space between the two margins, for writing the cue words and title indications. This space is sufficiently wide to write at least four words in lead pencil and five to six words if typewritten or written in ink. It must be borne in mind that the cue words used on either side of a title will also identify the location of a special title, even if only a few words are used. Some words can easily be abbreviated, for instance "close-up" (c.u.), "long shot" (l.s.) or other short identifications which make it easy in checking up.

Both the light change device and the printer are on pedestals and rollers and by means of a flexible armored cable the light control board can easily and quickly be moved into any desired position. It is used by some at right angles to the lamphouse, so that an operator sitting in a chair watching the negative passing through the aperture has but to glance a few degrees to the right to see the indicator. There is a distinct hum and click of the alternating current which indicates when the light change is happening. Usually in passing a new film through the machine for the first time, the operator can very easily hold his finger and thumb on the margin of the negative and feel the notches just before the change takes place. The light indicator on the control board is illuminated by a 6 volt automobile light which can be varied in strength by the little rheostat on the back of the board, to any brilliancy desired. When in the dark room it is still very easy to see the number bars and the paper strip, so that it is easy to check up. On this printer there is a revolving shutter working at the 16 mm. end. This shutter is always closed when the machine is stopped but when watching the well illuminated standard size negative image, it must be borne in mind that there is no shock to the eye. Also, the 35 mm. image is sufficiently large to observe not only what is passing through the machine but also the frame line, without the aid of magnifying glasses or strain to the eye.

PRES. COOK: The observation of the negative is not of importance. Observation of the positive aperture will not only confirm everything you want to know about the negative, but also whether any defect is showing at that point. The most common defect observed in the printing is the accumulation of dust, scale, and particles in the positive aperture. That occurs so continually that the gate is sometimes open for cleaning half a dozen times in the printing of a 1000 foot reel.

In our laboratory a complete air pressure system is available for cleaning these with great facility.

Every printer has his eye glued constantly on the printing aperture. It is impossible in the small images to depend on the unaided eye for inspection of any kind. On that account the facility of observation of the positive aperture is of the greatest importance.

MR. DEPUE: It is unnecessary to see the positive. The machine is constructed as a camera and not as a printing machine in common usage. Now, is it considered by camera men necessary to open up their camera in running a 400 foot roll to see if the aperture is free from dust and dirt?

The construction of the positive end of this daylight optical printer is exactly the same as a camera and there is no more chance of the aperture becoming filled with dust and dirt than there is in a camera, perhaps less chance. The fact that the magazine is loaded in the dark room with film taken out of the manufacturer's packing and placed in the magazine immediately, must be to the advantage of the operation, as there is no chance of dust and dirt to stick to the film in its course through the machine. This must be borne in mind in a machine of this type—it is dust proof. The only thing that has to be considered is the gummed paper that sometimes sticks to the end of a roll of raw stock. This might lodge in the aperture as the very last end passes through. When the magazine end is removed the aperture is brushed out with a small brush. Experience has shown that a very slight amount of dust is sometimes observed in the machine and that is due to dull perforators, but this dust does not lodge in the aperture which is so constructed as not to actually come in contact with the emulsion surface excepting on the very edges and outside of the actual aperture.

With regard to wastage, this is a very grave point and we are sure that if any such amount of wastage as that occurred in our optical printer, we would have to go out of business. The checking up of the light and what is going through the machine is so very simple and easy and the accuracy with which this control responds without watching is such that the wastage in our experience, and that is over 2 years, has been almost negligible. We learn from our customers that so constant in operation is this machine that one customer says that once knowing the negative is properly prepared, he allows the machine to operate without watching the operation. The operator goes about other things until the end of the roll is reached, as he is absolutely confident that the picture is being properly handled without his constant observation.

Desensitizers.—L. Lobel calls attention to a note by Dr. Strauss (Phot. Rund. 1926, *63*, 396) as to the occasional growth of a mould in a safranine bath, used prior to development, and that this can be prevented by the addition of 0.2 per cent of formaldehyde. In the case of pinakryptol the bath turns putrid and this can also be prevented by the above addition. Lobel states that he has found the same decomposition with basic scarlet N after it has been used a number of times. He ascribes this to the decomposition of fragments of gelatine, detached from the emulsion. (Sci. Ind. Phot. 1927, *7*, 4).

PRINTING MOTION PICTURE FILM.

Roscoe C. Hubbard.*

BY THE term 'Printing of Film' is very often implied the whole process required to produce from the negative a copy ready for screening.

In this paper we shall use the term in its pure meaning. Webster tells us that to 'print' means to 'impress'; so we will infer that 'printing of film' means to impress the picture upon the film by means of light. We will not concern ourselves with the physical or chemical action which takes place, but will confine ourselves to the mechanical means of making this impression.

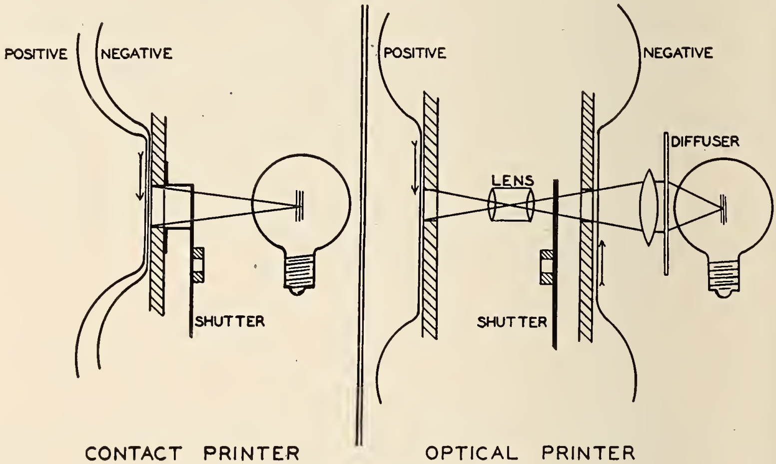

Fig. 1. Skeleton Layout of Contact and Optical Printers.

Film printing machines may be divided into two outstanding classifications, viz., optical printers and contact printers. By an 'optical printer' we mean any printing machine which uses an optical system interposed between the negative and positive while printing, Fig. 1. By a 'contact printer' we mean any printer in which the negative and positive are held in close physical contact while printing. The majority of printers in use for theatrical motion pictures are

* Consolidated Film Industries, Inc., New York City.

contact printers. The optical type is mainly used for educational and non-theatrical films, when printing from standard negative on to 28 or 16 mm. positive film.

I had hoped to consider optical printers in this paper, but find that the subject is too large, so will leave this type for a later paper.

The essentials for a contact printer may be classified as follows:

1. Means for holding a roll of negative and a roll of raw stock;

2. Means for unrolling negative and positive so as to feed them evenly to the printing mechanism;

3. Means for setting or changing the Timing Device—generally operated by a roller, which contacts with the edge of the film and functions when a notch or depression cut in the edge of the negative passes by;

4. Means for putting a slight pull or tension separately on the negative and positive;

5. An aperture where light can make its impression in a limited area;

6. Means of holding the film in close contact at the aperture, which is hinged or otherwise movable for threading the film;

7. Means for moving the film past the aperture either continuously or intermittently;

8. Means for guiding or centering the film sideways as it passes the aperture;

9. Means for feeding the film after it has passed the aperture, so that the pull of the take-up will not interfere with the printing mechanism;

10. Means for taking up or re-rolling the negative and positive separately;

11. A light source for impressing the film;

12. Means for varying the intensity of the light source or varying the amount of light reaching the aperture, so as to conform to the density of the negative and speed of the emulsion.

These twelve points are covered more or less successfully by all makes of modern contact printers. Now let us examine a few typical types.

Printer No. 1.

In Fig. 2 we have a well known step or intermittent type of printer.

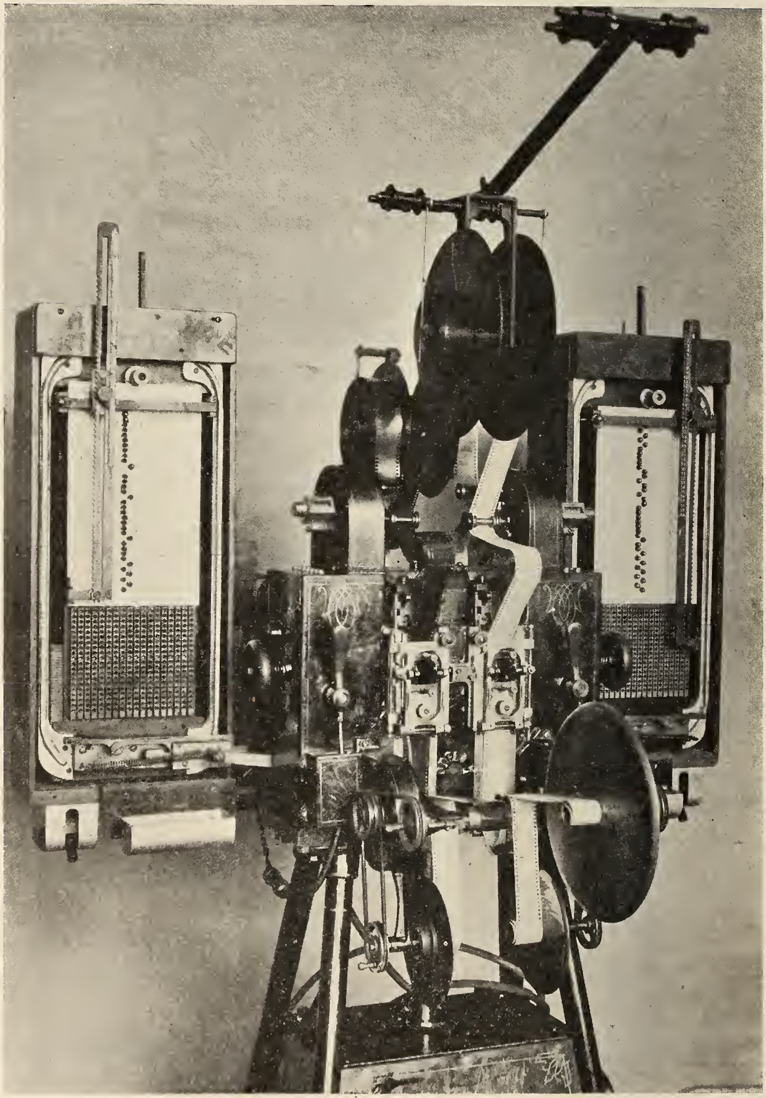

FIG. 2. Printer No. 1—Front View.

You will notice that the raw stock and negative are mounted on separate spindles, and pass down over a take-up or winding sprocket.

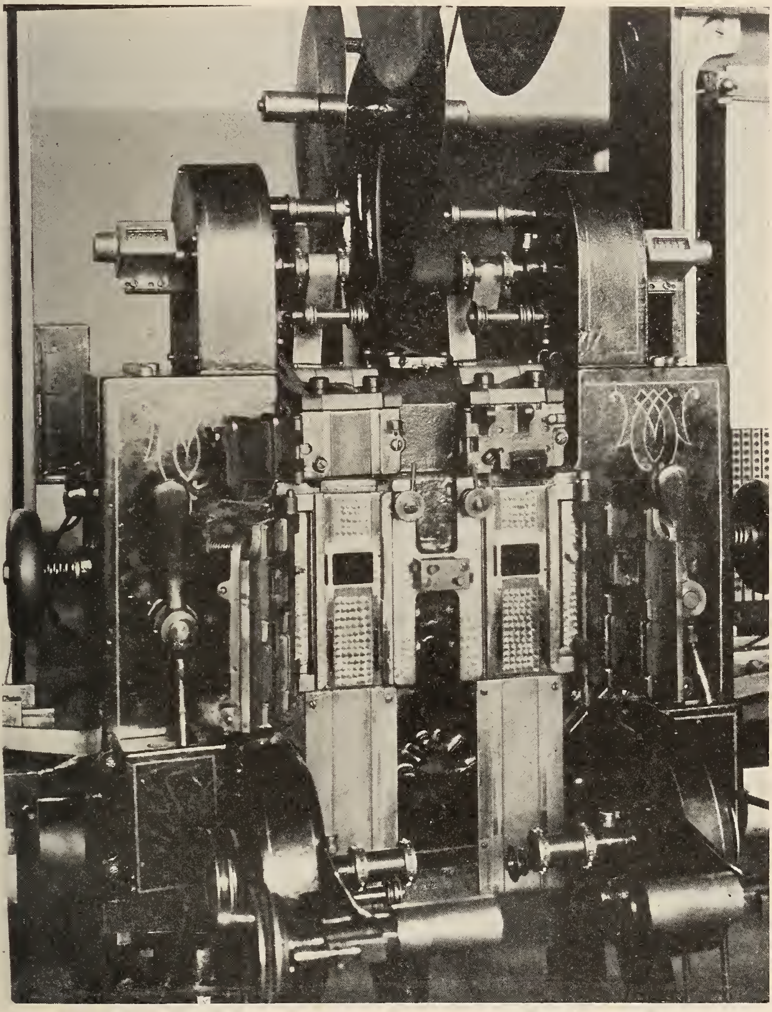

FIG. 3. Printer No. 1—Front View Close-up.

Here a loop is formed in both, and the negative passes under hinged tension shoes and past a light change operating roller.

A close-up of the gate mechanism is shown in Fig. 3.

The function of the negative tension is to properly aline the film at the claws or fingers. From here the negative and positive pass together under the aperture gate and before the aperture opening where the printing impression is made. The aperture frame is perfectly flat, being ground and lapped to a good surface. The two films are held in contact with a compound glass pressure plate, held in a hinged frame or gate. The inside glass is about the same size as the aperture, and presents a slightly convex surface to the film, and thus is presumed to expel any air bubbles which might be between films. The pressure glasses are pushed back so as to relieve the film while it is moved down by means of a push rod and operating cam. The gate and aperture are made so that they may be moved as a unit up or down slightly for framing; viz., centering the picture on the negative with the printer aperture.

Just below the gate are located the claws for intermittently moving the film, and opposing these on the gate are two steel pressure shoes which hold the film in engagement with the claws. The claws are operated by means of a crank and rocker motion. It is interesting to note that in this printer the claws do not move down along a parallel line, but transcribe a slightly curved line. After the film leaves the claws it forms a loop and passes over a take-up sprocket, and is re-wound separately on the take-up spindles.

The light source in this printer, as shown in Fig. 4, is an ordinary incandescent lamp bulb—generally a 60 watt frosted bulb is used. The light source may be adjusted with regard to its distance from the aperture, so as to standardize the intensity with that of other printers. Interposed between the light source and the aperture is a revolving segment shutter, shown in Fig. 5.

The intensity of light is varied by an automatic rheostat consisting of 17 resistance coils making 18 light steps. The face of the rheostat has 30 or more rows of holes through which plugs may be inserted to contact with bars beneath. A movable bar, with shoes mounted underneath it, passes by steps down the face of the rheostat and contacts with plugs inserted in holes. A card with holes punched in proper places is furnished to the operator with each roll of negative. This he places on the face of the rheostat and inserts plugs accordingly. The operation of the rheostat is as follows: before starting the printer, the operator sets up the card and raises the movable bar to the extreme top. As the negative feeds through the printer, a notch in the edge and at the beginning of each scene or light change allows the light change roller to make an electrical contact, which excites an operating magnet, allowing the bar to drop one step and contact

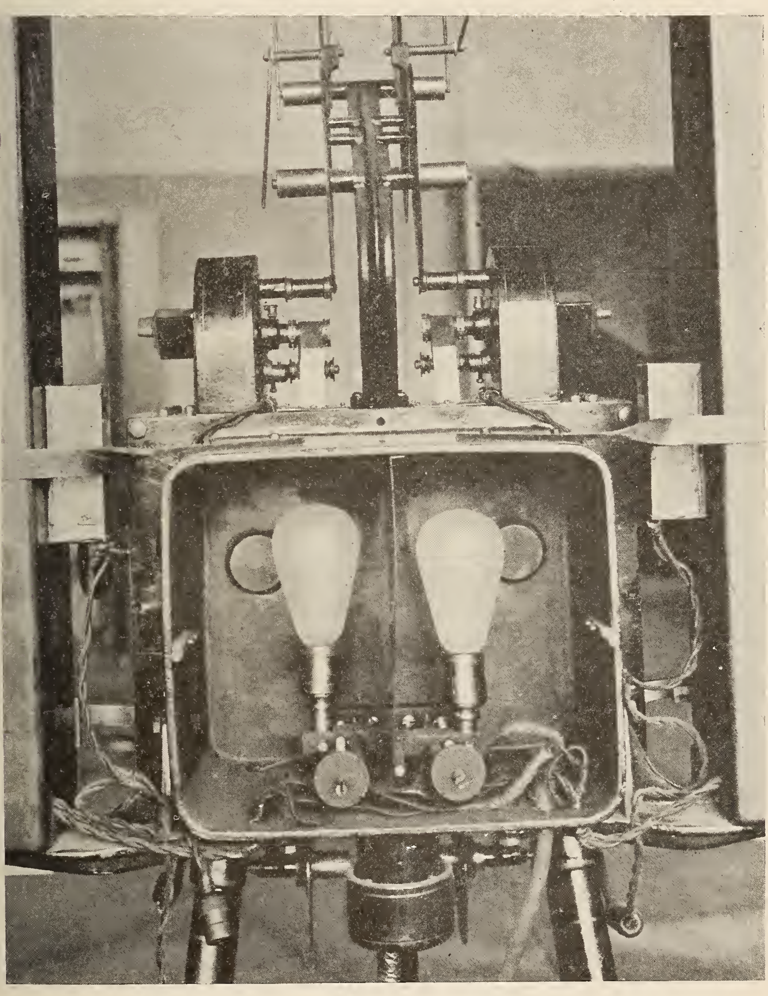

Fig. 4. Printer No. 1—Back View. Light-box Cover Removed.

with the proper plug for the scene following. This printer operates satisfactorily at a speed of not over 24 feet per minute or 1440 feet per hour.

A rheostat light change device may not be operated at a greater rate of speed, because the change in the temperature of the lamp filament does not occur rapidly enough. At this speed a change of

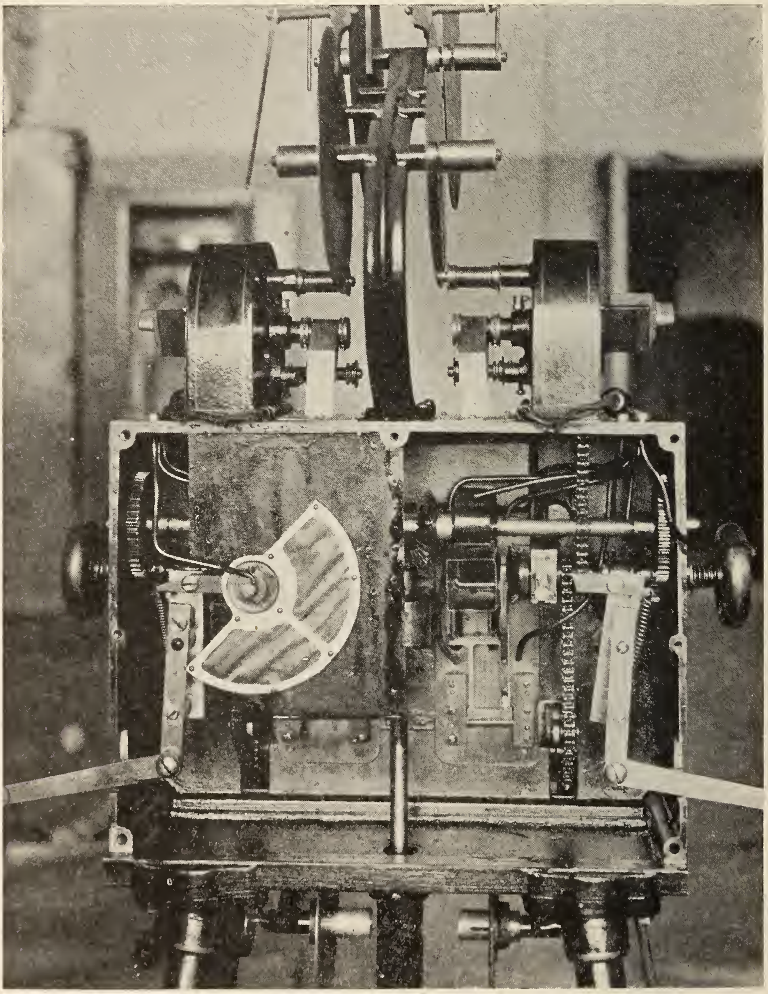

Fig. 5. Printer No. 1—Back View. Light-box Removed.

light of five points or more will not be fully consummated within the elapsed time required for the movement of the film. Another feature of this machine is that it is built in pairs on a unit frame, so that one operator may handle both sides.

Printer No. 2.

Another contact step printer is shown in Fig. 6. We have the usual negative and positive roll holders and unwinding sprocket. Notice that the tension device on both negative and positive is of the roller type and that the rollers bear on the emulsion side of film, Fig. 7. This insures freedom from scratches and abrasions along the edges of the film from the tension device.

The light operating roller is placed where the negative passes over a large roller, so that buckling of the negative may not affect it. The opposing flange of this roller is a loose flange with a spring back of it, thus keeping the negative against the side with the operating roller. This is especially useful in printing old negatives which have shrunken considerably. These give a great deal of trouble on a type of contact roller described under *Printer No. 1*, not only on account of variations in the width of negatives, but on account of the tendency of old negatives to buckle.

In this case the aperture and gate are of the curved type, viz., at the aperture the negative and positive pass around a curve, thus insuring perfect contact without further devices.

Just above and below the aperture opening, there are mounted on the aperture frame two small rollers and on the gate are mounted two or three opposing discs. A curve in the film is thus formed about 2 inches in diameter. Of course the aperture and gate are so made that the film touches only the surfaces of rollers, and the centers of rollers are recessed, so that we eliminate all tendency to scratch at the aperture. Double claws are used which engage two perforation holes on both sides of film. The claws are operated by crank and cam motion, and transcribe a parallel line with film. The aperture and gate are made so they may be moved as a unit up or down for framing. The light source in this case is a 150 watt projection type lamp, especially made by the Edison Lamp Works of the General Electric Co. Interposed between the light source and the aperture is the revolving segment shutter, Fig. 8. Between the shutter and light source there is a diffusing medium of ground glass, and between the shutter and ground glass, a diaphragm. This diaphragm is automatically operated to regulate the amount of light reaching the aperture.

The diaphragm opening is a rhomboid so as to give an even distribution of light at the smaller openings, Fig. 10. The operating mechanism of the diaphragm consists of a spring-operated segment and a mechanical setting arrangement, in which the set-up is deter-

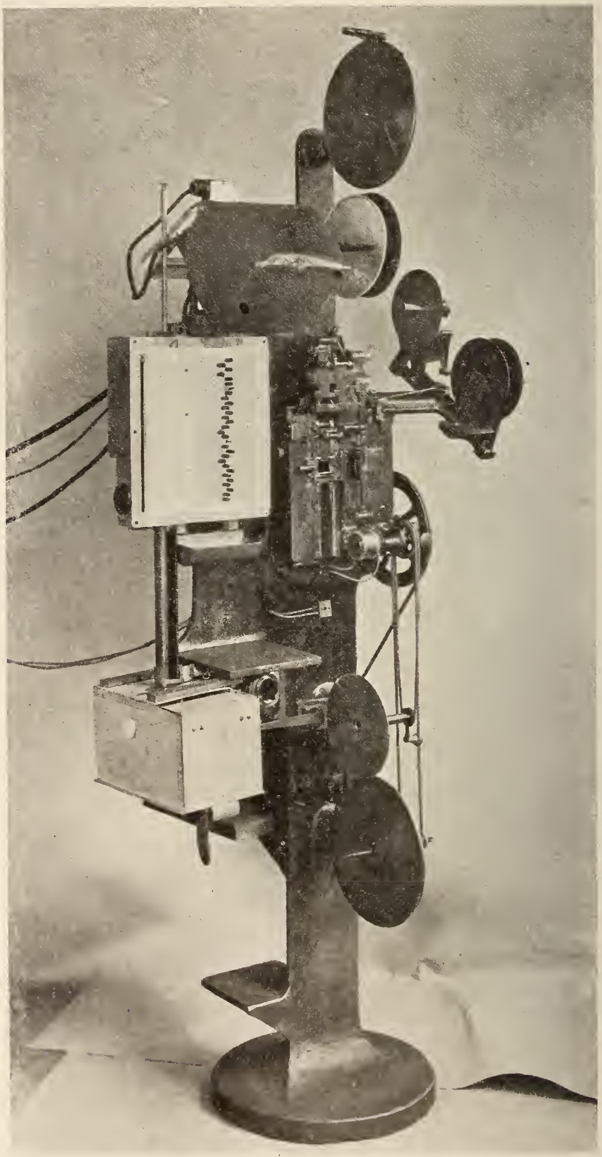

Fig. 6. Printer No. 2—Front View.

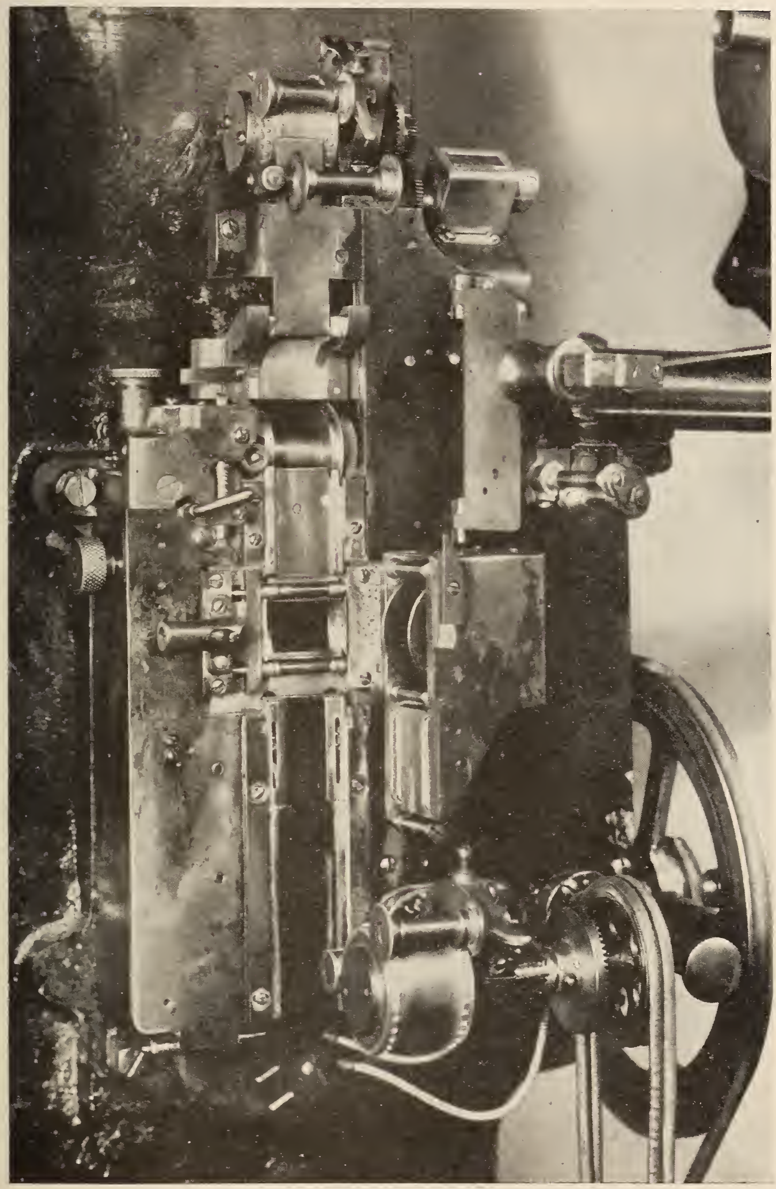

FIG. 7. Printer No. 2—Front View. Close-up.

mined by means of stops, actuated by a series of magnets. These magnets are incited by a switchboard very similar to the rheostat control board described under *Printer No. 1*. In fact, in building this device we used what were formerly the rheostat light changes, for

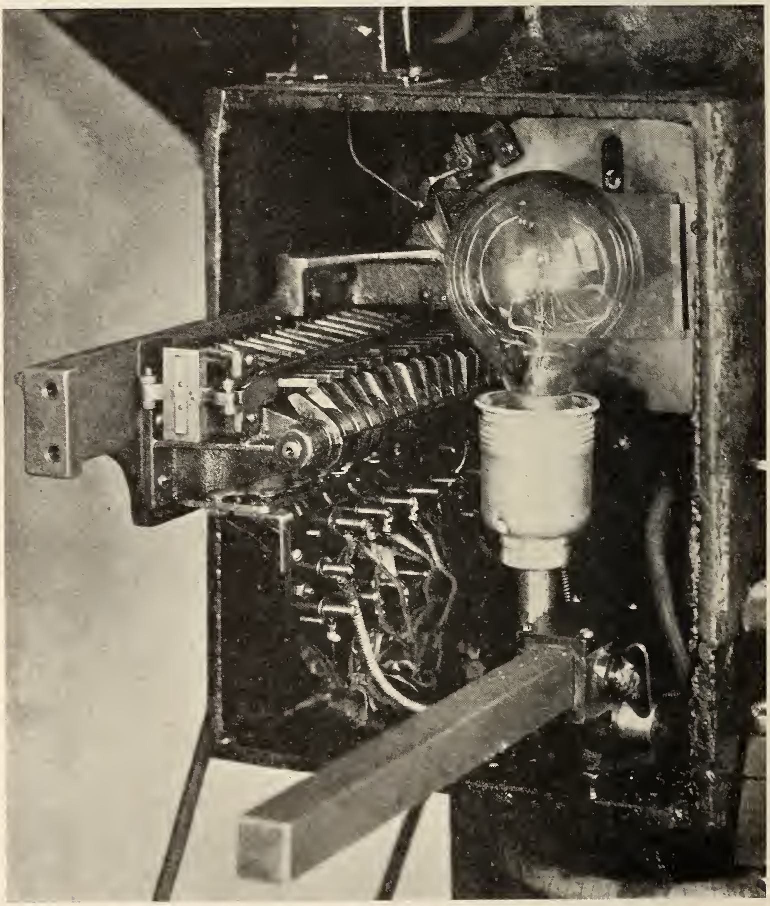

FIG. 8. Printer No. 2—Back View. Light-box Removed.

this switchboard, Fig. 10. The great advantage of a diaphragm light change is its speed of operation. Light changes of 10 points or less can be made in less than 1/30 of a second. Another advantage of this type over *Printer No. 1* is that printer cards may have spaces for a description of the scenes. This has been found essential for the most efficient printing.

This printer, No. 2, operates satisfactorily at a speed of 40 feet per minute or 2400 feet per hour—the limiting element in this case

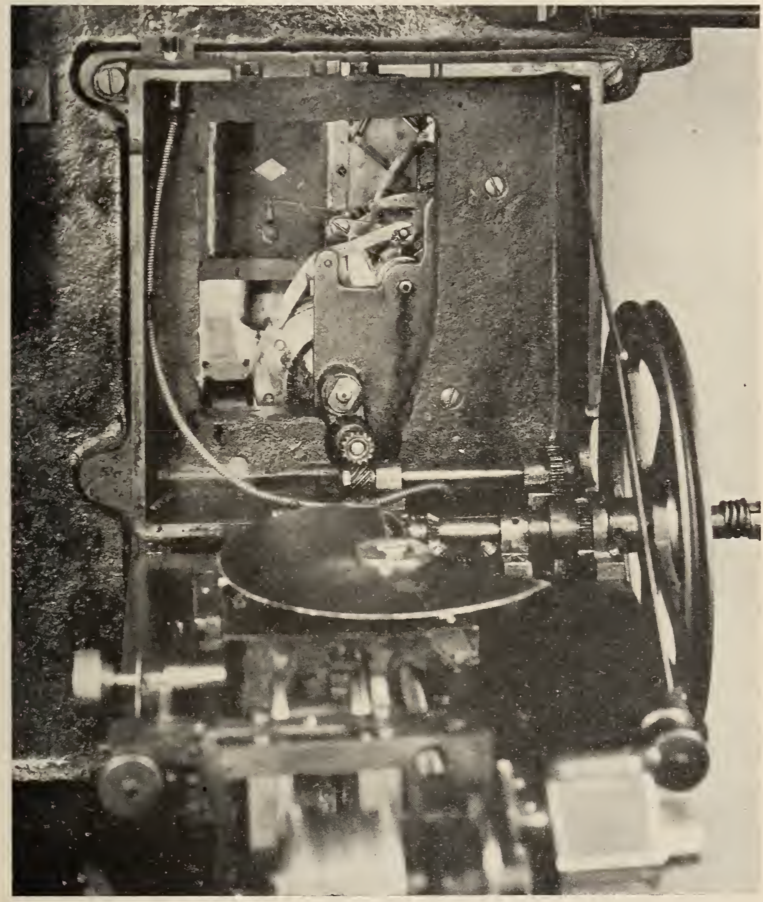

FIG. 9. Printer No. 2—Front View. Mechanism Open.

being proper handling of film at the intermittent movement and the amount of light required at the aperture.

Printer No. 3.

Another contact step printer is shown in Fig. 11, which is a later model of No. 2. The principles are similar, except for two things.

1st. There is a convex curve at the aperture instead of a concave one as in No. 2. This change was desirable because it gave a more even distribution of light than either the flat or the concave aperture.

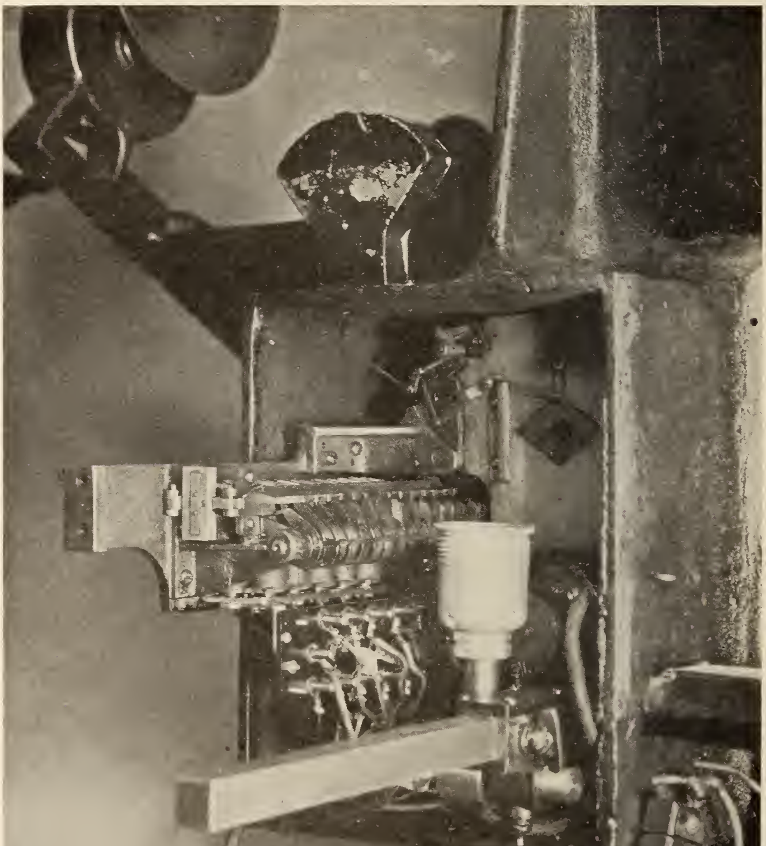

Fig. 10. Printer No. 2—Back View. Light-box, Lamp, and Ground Glass Removed.

It also gave better vision during printing, and made the machine more fool proof in several ways.

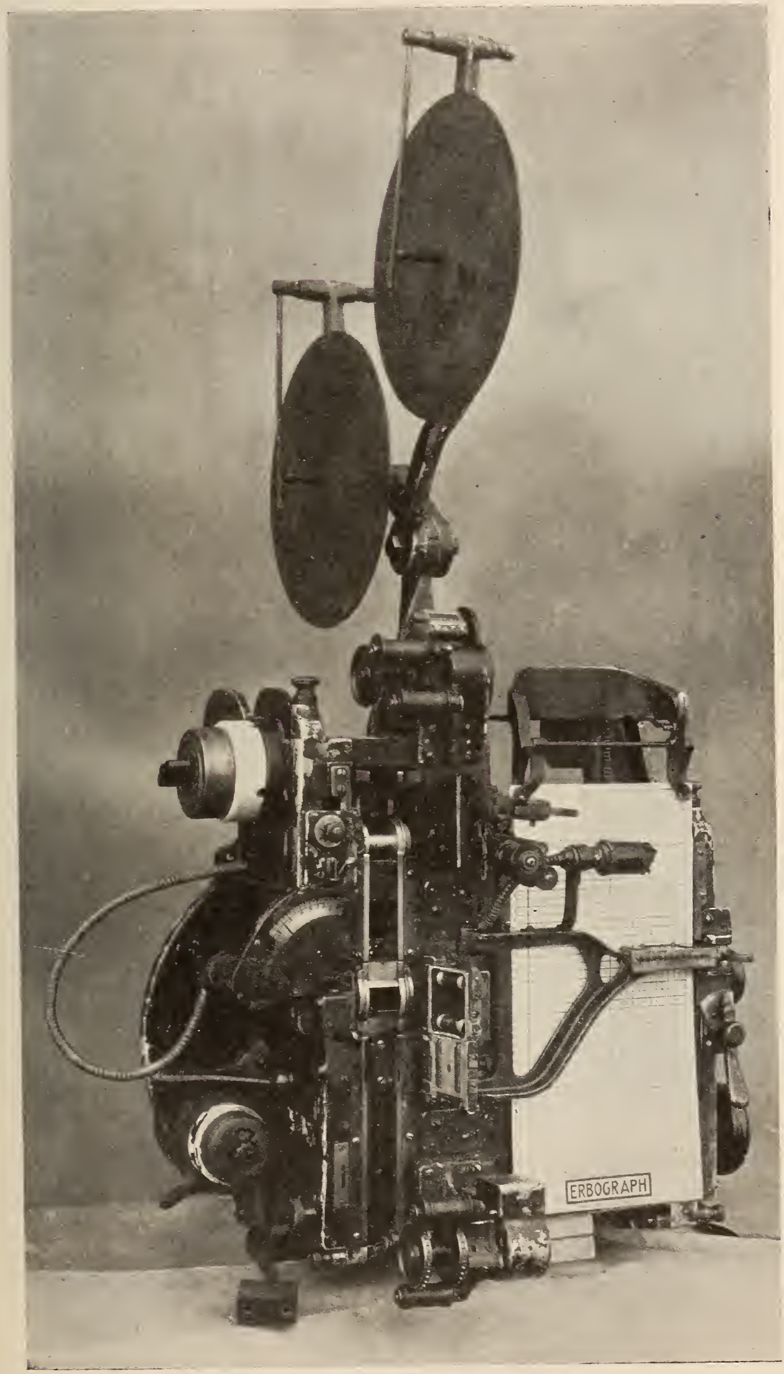

FIG. 11. Printer No. 3—Front View.

2nd. The light change is mechanically operated. The dropping of the contact roller into the negative notch merely starts a train of mechanical movements which set the diaphragm device, and reset the spring segment for the following scene. The contact roller

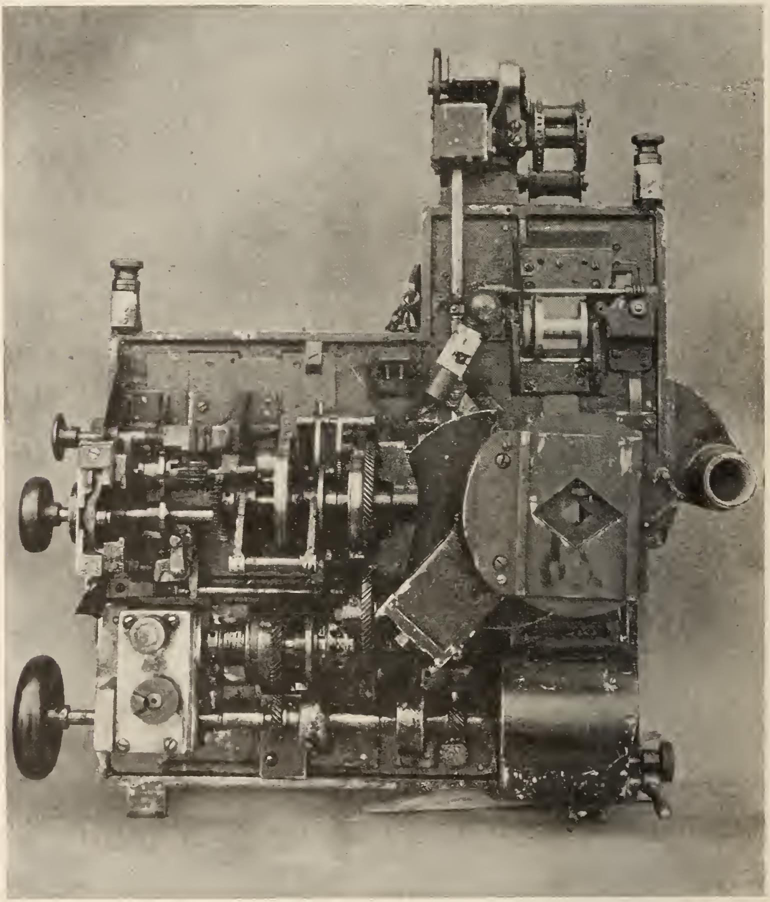

FIG. 12. Printer No. 3—Back View of Mechanism.

operating mechanism may be set to vary from three pictures to eight pictures, by means of a knurled knob and graduated disc positioned adjacent to the contact roller. Many negatives are received already notched for light changes and very often these notches are positioned to a standard not in use at the receiving laboratory. With this device one is able to correctly print the negative without alteration. The printing card is attached to a carrier which moves it up one scene or

Fig. 13. Printer No. 4—Front View.

space when the light-change mechanism operates. Closed over the card is a hinged arm carrying fifteen spring pins which pass through holes punched in the card and act as stops for the setting mechanism.

Fourteen of these pins are used for primary changes and one for secondary changes, thus giving twenty-nine light changes. The number of scenes is only limited by the length of the card. This

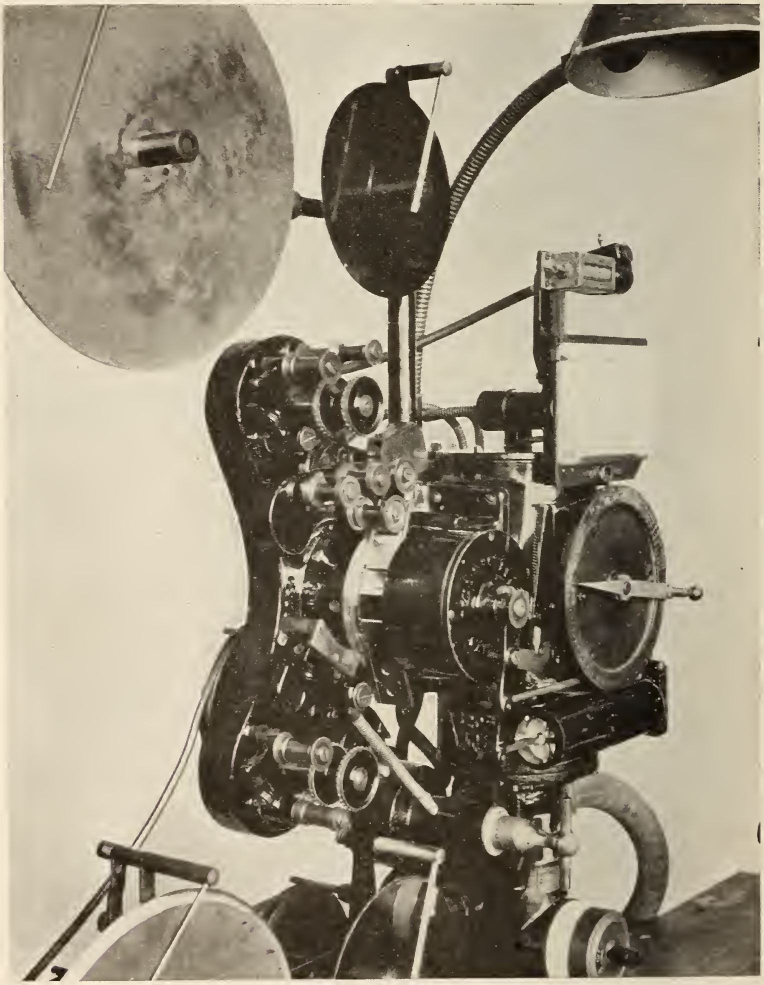

Fig. 14. Printer No. 4—Front View, Close-up.

printer was used successfully to print negatives assembled in 1000 ft. rolls. This printer operates satisfactorily at 50 feet per minute or 3000 feet per hour.

A back view of the mechanism is shown in Fig. 12.

Printer No. 4.

In Fig. 13 is shown a Continuous Contact Printer. The usual roll holders and unwinding sprockets are provided. Note the ingenious tension device, Fig. 14. This consists of two weighted rollers which separately rest on the negative and positive, and draw them taut between the unwinding and feeding sprocket. Notice that the light operating roller is positioned as the negative passes on a curve. Both the positive and negative pass over a convex curved aperture, and the film is fed through by sprockets placed by the sides of the aperture.

The size of the sprocket and curve of the aperture are so determined as to allow a proper correction for a theoretical medium of negative shrinkage. The gate in this machine is very accurately and rigidly constructed and is really the determining factor of proper curve and contact. The aperture is equipped with a low pressure air connection, which furnishes a gentle outward pressure, assuring contact between negative and positive. This air pressure tends to force the negative against the positive, and the positive is thus forced against the face of the gate. This feature also tends to prevent the back of the negative touching any part of the aperture. Since this machine is continuous in action, no shutter is required. The light-change is made by varying the size of the aperture opening. The operation of the light-change is semi-automatic; viz., a spring segment or pointer is set by hand for the coming scene, and the contact roller, when the negative notch passes, makes electrical contact which incites a magnet which in turn releases the segment that sets the aperture to the predetermined opening. The operator must be on the alert to again set the pointer for the next scene. A rear view of this printer is shown in Fig. 15. The manufacturers have constructed a later model which is fully automatic, Fig. 16. The light opening is varied by means of a wheel, carrying keys, Fig. 17. Each key represents a scene or light change. The operating face of the key has two surfaces which contact with plungers operated by the light-change magnet. These surfaces are varied to conform to the required light steps, and each key is numbered accordingly. In operating, one must insert the proper keys in sequence to conform to the timing of the negative. On both the semi-automatic and the automatic printers there are twenty-two light steps. The semi-automatic has only space for fourteen scenes on one card, but by changing the cards more can be obtained. The automatic printer has provision in the light key wheel for about one hundred scenes. The light-source of this machine is a 50 watt frosted bulb. Since this machine is continuous and as the light change is mechanical, the only limitation

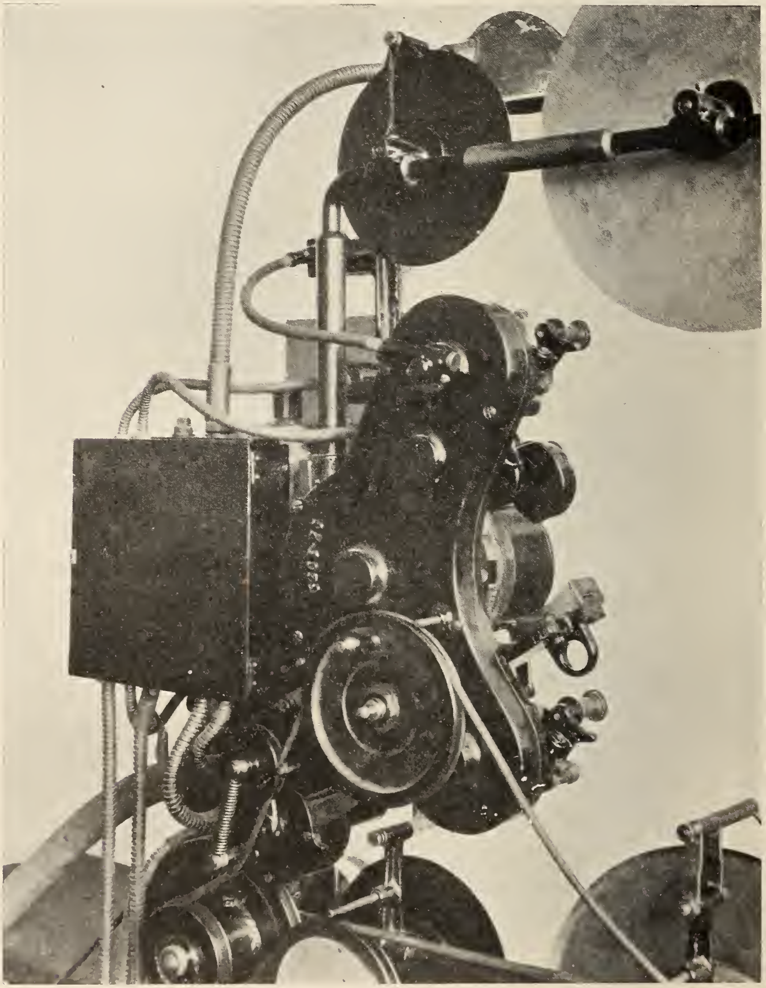

Fig. 15. Printer No. 4—Back View.

in speed is proper handling of the film and the time limit required for the operator to make the light change setting. This machine will operate satisfactorily at 50 to 60 feet per minute.

Now let us consider what are the desirable mechanical points in film printing. Continuous printing is advantageous on account

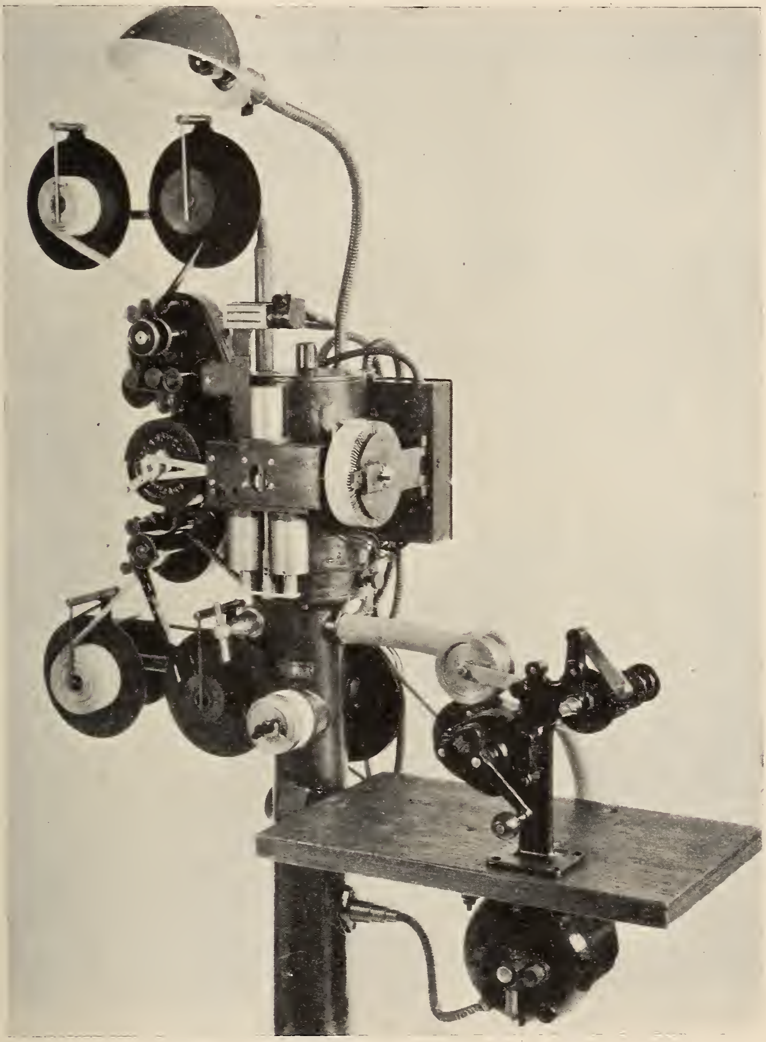

FIG. 16. Printer No. 4—Automatic Type.

of speed, when the negatives are not badly shrunken and when you are making full prints. The automatic continuous printer has the disadvantage that the operator has no way of checking up once the printing is started. All continuous printing requires very careful operations and care of the machines, because the operator cannot see the actual progress of printing as in the step printer. The step printer has proven better for general work, as it is unaffected by shrinkage of the negatives. Also one may stop or start printing on the picture, thus eliminating cut-outs on tell-tale prints, reprints or replacements. Better and surer contact may always be obtained by handling the film on a slight curve. The light source should be a recognized long-life lamp, which has a life curve, the greater portion falling on a straight line. The current for printing lamps should be obtained from a motor generator set with an automatic voltage

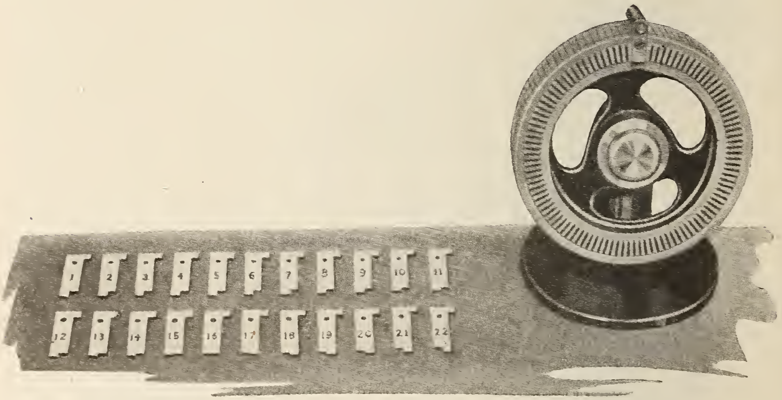

Fig. 17. Printer No. 4—Automatic. Key-wheel and Keys.

control attachment, so that the voltage may be maintained within plus or minus $\frac{1}{2}$ volt. A variation of one volt will mean almost one point of light on the light control.

In Fig. 18 two motor generator sets manufactured by the General Electric Company are shown. The one on the left is a later type and operates with a minimum of trouble and adjustment.

The light-change device giving most accurate results is the diaphragm type.

A very important point in proper printing is the timing of the negative. This may be done very well by visual examination by an experienced timer, provided he is furnished with key tests of the negative. These key tests are necessary so that timing may be standardized.

It is good practice to test two or three rolls of negative from each picture being timed; the timer selecting scenes which are expressive of the general trend of the picture. These tests are then developed

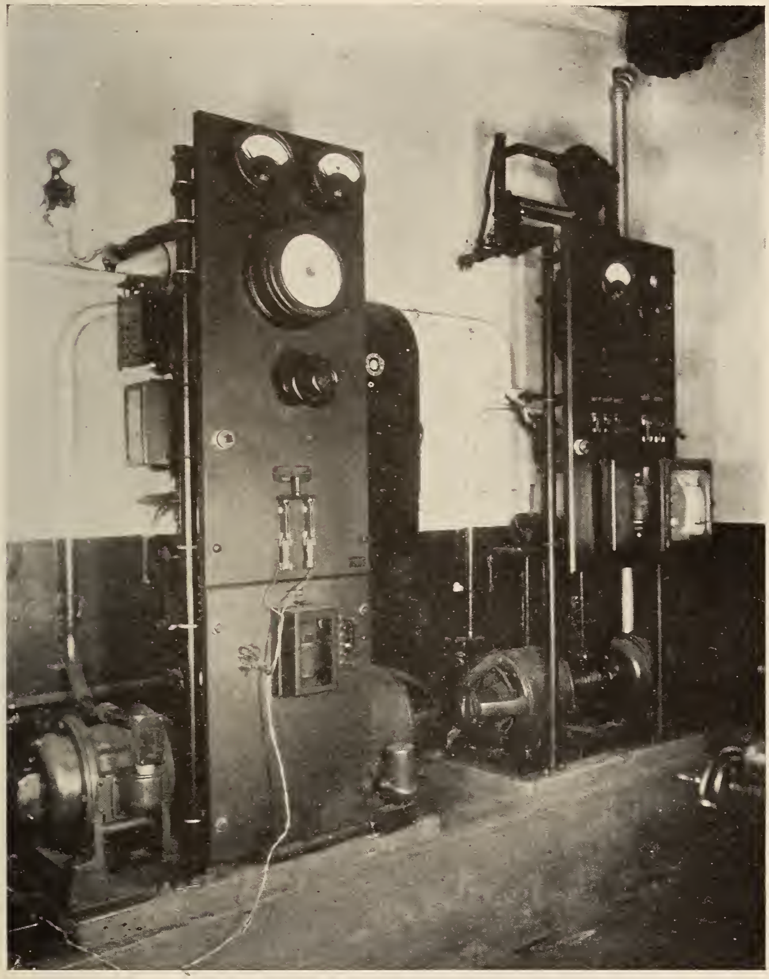

FIG. 18. Motor Generator with Automatic Voltage Control.

for a standard time in a solution of standard strength. The timer then examines the tests and with this observation as a basis, times the picture.

A good machine for making key tests is shown in Fig. 19. The negative and positive are securely clamped together over an aperture taking in fifteen picture frames and this portion is given fifteen different exposures, by means of a drum, carrying a focal-plane

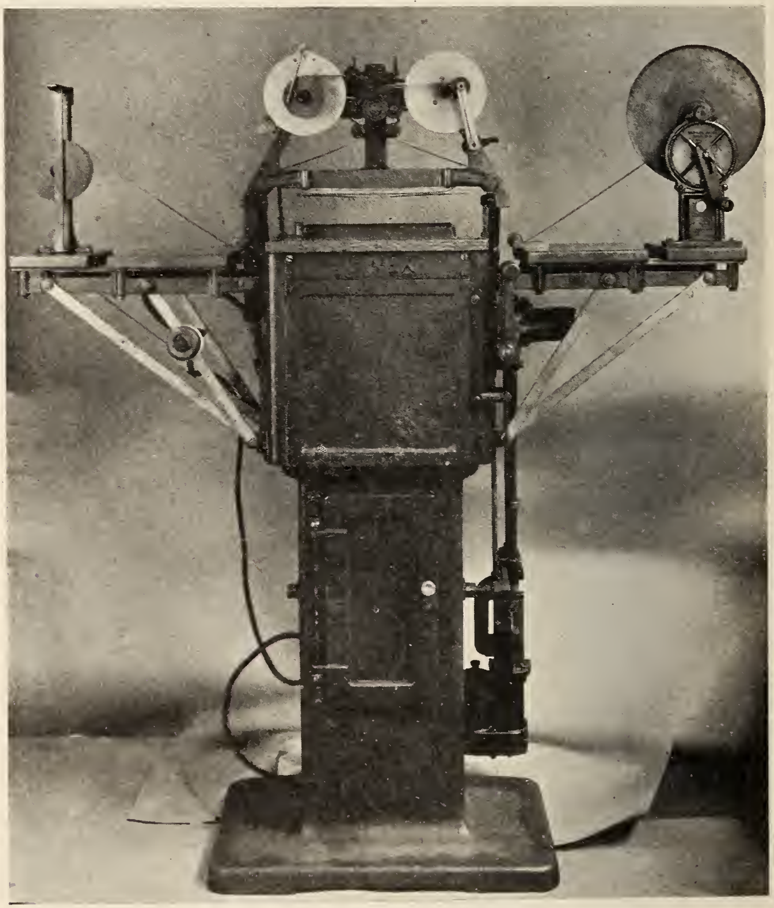

FIG. 19. Negative Timing Machine.

shutter, which is rotated at constant speed. The openings in this shutter may be adjusted to suit the printer steps, Fig. 20.

A great help to efficient and rapid printing are printing cards which give the operator all the necessary information, Fig. 21. You will notice that the card for Printer No. 1 gives no space for any information. This is a great handicap. The card for Printer No. 2 gives space for both scene number and light number, and a small

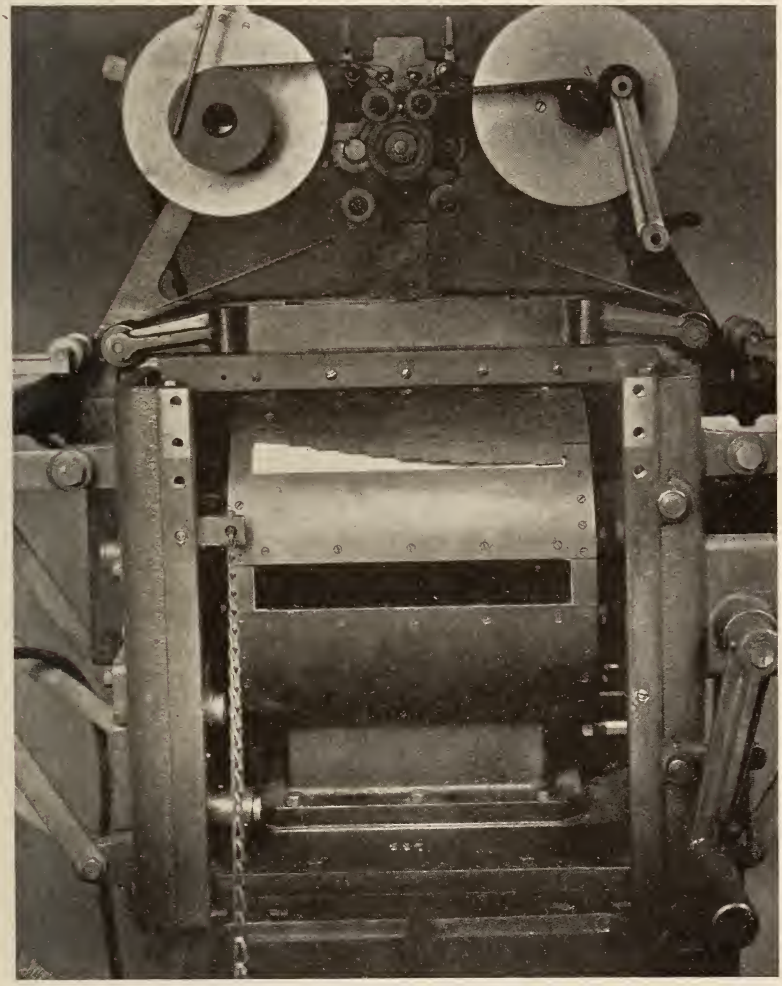

FIG. 20. Negative Timing Machine.

space for a description of scene. This one has been found fairly satisfactory, but is not adequate. The card for Printer Nò. 3 has been found adequate in all respects. The card for Printer No. 4 has

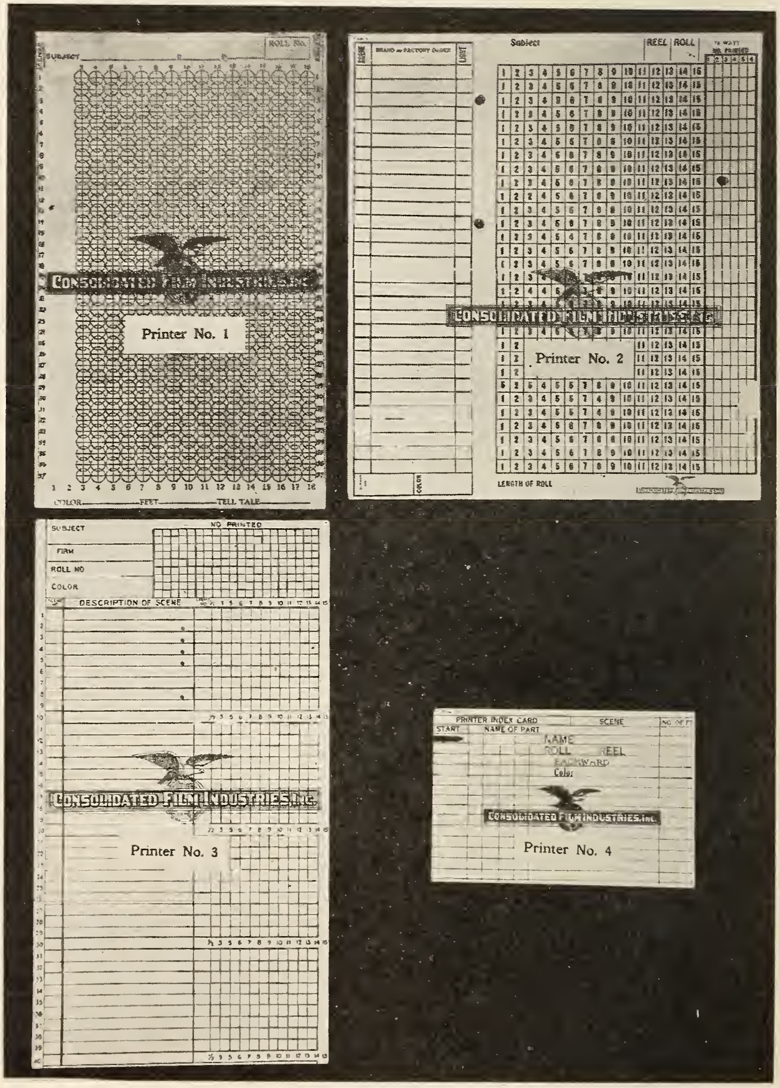

FIG. 21. Printing Cards.

proper spaces allotted for all information, but is entirely inadequate for the number of scenes required by the average negative roll.

It is the practice to have several cards for each roll. This requires the operator to make a very rapid change of cards and there is a very flagrant chance for error. The automatic type of Printer No. 4 has no card holder or follow-up indicator, except a narrow band which fastens around the key wheel, and which is entirely inadequate. I believe that there is a large field for further improvements in the Printing of Motion Picture Film.

DISCUSSION.

Mr. Capstaff: Can you tell me what the radius of curvature is on the film track? Also, do I understand that the pressure plate on the curved track contacts only on the perforations? Also, what distance is the ground glass diffusing screen from the film?

Mr. Hubbard: The radius of curvature is about two inches, and you are right in assuming that the disk contacts only with the edge of the film; that is, the disks are partially in the perforation and partially on the outside edge beyond the perforation. The ground glass in this case is probably about three and a half inches away from the aperture. I don't know that this distance is absolutely necessary. Of course, by keeping ground glass close to the aperture a smaller light source can be used. The ground glass reduces the useful light about 50 per cent.

Mr. Palmer: If you were starting out to design a new printer, would you design it as a projection printer or as a contact printer?

Mr. Hubbard: My experience with optical printers is that you run into a great many more troubles. I should not do any projection printing if I could do it by contact.

Mr. Fritts: Is Mr. Hubbard familiar with the voltage controller now put out by the G. E. people, which seems to me to be very much simpler than that which he showed, and which we have used very successfully in Rochester but which does not have the motor generator set. If this is preferable, on what grounds is it so?

Mr. Hubbard: In all our plants we have alternating current, and it is not as good as direct current for printing. Therefore, we use motor generators to give us D.C.

Mr. Kelley: We print with six volt automobile headlight lamps, each one on an individual battery, which gives as much light as 150 volt lamp for printing.

Mr. Crabtree: I am glad that Mr. Hubbard has devised a satisfactory mechanical means of controlling exposure during printing. When in London about two years ago I noticed two new methods of light control. The Lawley method consists in inserting metallic staples in the film on opposite sides. The first staple as it passes the electric contact changes the light, and the distance between the staples determines the intensity. Another laboratory was placing little strips of celluloid over the perforations to secure the same result. These methods ensure that if there is a mislight on any particular scene the succeeding scenes are not ruined.

Mr. Hubbard: We have experimented with 6 volt lights and found them very satisfactory, but as it would mean changing over all our equipment, we have not installed them. We hope to in the future.

With regard to the metal clips mentioned by Mr. Crabtree, we looked into this at one time, and an objection was raised as to the possible damage to the negative by putting these in.

Pres. Cook: Would there not be a lag in the change of the light due to the necessity of the film to travel the distance between the staples before the intensity is determined?

Mr. Crabtree: The light control which I saw ensured that no lag occurred.

In reply to Mr. Hubbard, one would think that the staples might injure the perforations but this did not seem to happen. The staple was removed by clipping off each edge in a special machine. In any case the damage resulting was much less than that which happens to negatives handled by several different laboratories when each one employs a different light change punch.

Pres. Cook: It was very interesting to me to note Mr. Hubbard's remark that the difficulties encountered in optical printing are much greater than with contact printing. It so happens that our experience has been almost entirely with optical printing, and while we have realized the enormously increased number of things that can go wrong, it is refreshing to note that the mortality is as large as mentioned by Mr. Hubbard.

THE TELEPHOTO LENS IN WILD BIRD AND ANIMAL PHOTOGRAPHY.

NORMAN McCLINTOCK.*

IT WAS about 1908 that I first commenced to make motion pictures of wild song birds. My camera was an English Urban box camera, fitted with a 3 inch Carl Zeiss F 3.5 lens and holding 150 feet of negative. I well remember that my first subject was a house wren. Inasmuch as this bird is one of our smallest species, I soon found that, in order to secure an image of satisfactory size for projection purposes, I was obliged to get closer to the wrens than met their approval.

It was not long, therefore, before I attempted to apply a 6 inch Goerz lens having a working aperture of F 6.8, which was too slow for our Pittsburgh light. With this outfit I struggled along, with but poor results, until 1914. Though I did not succeed in making any pictures during that period which I dare show now, yet the time was not wasted, as I was preparing myself for the use of better tools, which finally I came to possess.

At that time, though the motion picture industry was well under way and was advancing by leaps and bounds, yet not a single individual in America, as far as I know, had ever recorded successfully in motion pictures habits of any of our American song birds.

I saw then, as I still see now, vast possibilities of wild bird motion pictures that should awaken, as through no other visual method, an interest in the study of birds. It was, therefore, with this object in view that I took up what was to me the fascinating work of wild bird cinematography.

There is one goal for which all bird photographers strive in the making of bird pictures. It is the securing of large size images of these small creatures. In other words close-ups. Of course there are but two methods of accomplishing this: either by the use of the regular moving picture lens at close range or by a telephoto lens at a distance.

I started my motion picture bird work, with the song birds on my small suburban home in Pittsburgh as my subjects. For various

* Photo Naturalist, University of Pittsburgh.

reasons, it did not seem practical to me to use a bird blind. None of you has to be an ornithologist to know that no self-respecting wild robin would permit a camera man to approach within three feet of it, in order to take its picture. And yet you would have to be as close as that to secure the same size image with a 2 inch lens, as you could secure at a distance of 25 feet with a 17 inch lens. I have found that the robins on my home grounds have what I term a critical distance and that if I remain outside this distance, the birds will permit me to do as I please within reasonable limits. The critical distance of my robins is not far from 25 feet. And so you see why it was that very early I began to long for a 17 inch lens, though I did so in blissful ignorance.

In 1914 I became the fortunate possessor of a Bell and Howell camera. I no sooner had it than I secured from the Dallmeyer Co. in England both their 12 inch and their 17 inch cinematograph telephoto lenses, which then had a working aperture of F 6. I believe, by the way, that this 17 inch lens was the first one sent to America.

Some experimental work soon demonstrated that the optical properties of both lenses were excellent, but that they were weak mechanically. Therefore, one of the first things I did was to have the Brashear Co. of Pittsburgh, makers of celestial telescopes, alter the focusing devices, which they greatly improved.

One of the primary requisites in all photography, especially with telephoto lenses, is precision in focusing. Therefore, I was most fortunate in having the Bell & Howell camera, with its ground glass lens image magnified a couple of diameters.

Photographic tests with the 12 inch and 17 inch lenses were most encouraging, at least when measured by the rules of still photography. I add this qualification because I had yet to learn that good screen results do not necessarily follow from good quality of negative, as examined in the hand.

During the summer of 1914, I felt sure I had some most excellent 17 inch lens robin negatives, until I printed and projected the film only to find that while the focus was good yet there was an objectionable dip to the picture every eight frames. In other words, there was recorded on the screen the downward thrust of the crank handle every turn. Then followed various attempts to eliminate this motion.

The first thing I tried was a unification of the three tripod legs, by bolting them to a triangular metal plate near the top. This provided a more solid base. Then I made a metal ring or support which

I attached to the 17 inch lens mount, Fig. 1. This ring, which was split, was provided with a screw clamp at the top and a hinged socket at the bottom for receiving a brass rod or truss. The hinge permitted any desirable change in the angle the truss made with the front tripod leg, to which it was attached. In order to provide a variable length

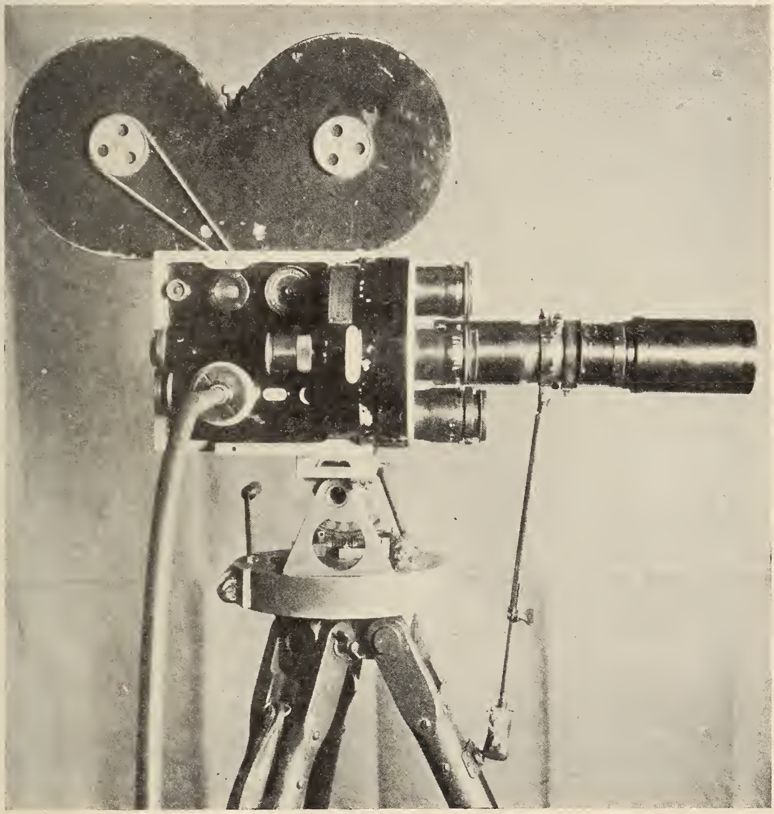

FIG. 1. Showing Lens Truss and Cranking Cable.

in the truss, it was made in two parts; the upper part a solid rod acting as a plunger in the lower part constructed of tubing to fit the rod. A screw clamp at the top of the tubing provided rigidity for any length of truss desired. Lastly, the lower end of the truss was attached to the tripod leg by a ball and socket clamp, which gave the necessary freedom of adjustment. This outfit gave excellent results and seemed wholly satisfactory for such subjects as nests, where it was not necessary to follow a moving object. The arrangement, however, proved entirely inadequate when it came, for instance, to following a robin hopping rapidly along the lawn listening for earth worms to dig up.

With the foregoing arrangement for steadying my big lenses, I worked until about 1916. Then, in order to meet my constant need

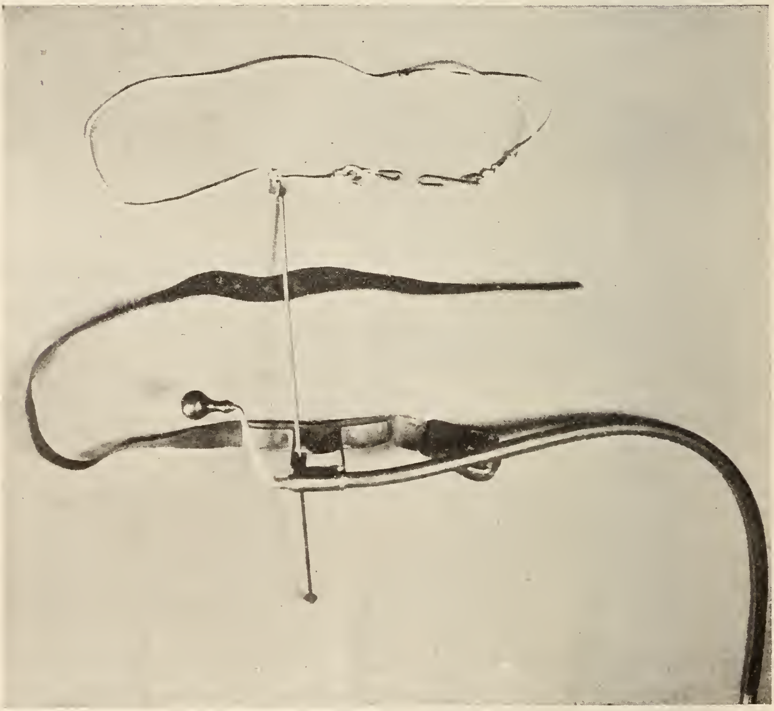

FIG. 2. Cranking Device.

of following rapidly moving objects with my telephoto lenses, I discarded the truss arrangement and substituted for it a flexible cable, for applying the driving power to my camera. I reasoned that by entirely removing from both the camera and tripod the objectionable results of hand cranking I should have perfect freedom in panning the camera and still secure rock steady pictures, even with my 17 inch lens.

I will now describe my method of operating the flexible cable.

I procured a stout leather belt to fit my waist, Fig. 2. This belt had riveted to it on the front right hand side a contrivance for holding the driving end of the flexible cable, which was fitted with the same square shaft as on my camera, so the cranking handle would fit both. The contrivance on the belt, just mentioned, was raised 4 inches above the belt, so as to allow the necessary freedom of action when turning the cranking handle.

In order to steady the affair so as to secure a reasonable smoothness in the grinding I used two braces. These consisted of steel rods screwed into a brass block which supported the end of the cable. The lower brace was a rod 6 inches long, with a knob on the free end that rested against the thigh of my right leg. The upper rod was $11\frac{1}{2}$ inches long, with its free end securely tied around my chest.

When operating the cable it was a simple matter, by assuming a very slight crouching posture, to place a stress on the two body braces and thus steady the cable end, attached to my waist as described. This device not only secured surprising steadiness in cranking, but also permitted the freedom of both hands, the left for panning and the right for cranking. This somewhat peculiar outfit also had the advantage of permitting me either to sit or stand and to move or walk about with more or less freedom. The scheme, as I have described in detail, worked very well; so much so that I long ago discarded the triangular tripod brace.

I have now been using a flexible cable and this method of working for the past 10 years without being able to improve upon it for telephoto field work.

It has been my experience that up to and including a 6 inch lens a flexible cable is not essential with my hand driven camera. An 8 inch lens, however, seems to be the dividing line. Sometimes, I have used it successfully without my cable and at other times I have wished I had used the latter. At no time have I ever been able to successfully work either my 12 or my 17 inch lens without some steadying device.

So far, I have made no reference to my telephoto finders, which are an all important factor in wild life work.

For all of my series of lenses above 4 inch focal length, I employ direct view finders. For my Bell & Howell camera I made a brass frame with a rectangular opening that gives me the field of view of my 6 inch lens. This brass frame fits into the standard dovetail slot on the left side of my camera and is used for the regular finder lens. The brass frame is slotted for receiving masks, for use with my 8, 12 and 17 inch lenses. On the rear side of my camera, in horizontal line with the mask holder mentioned, I have a small slotted receptacle for receiving a removable peep sight. This peep sight is adjustable horizontally, so as to offset the difference in parallax between this finder system and the taking lens, as determined by the distance of the subject photographed from the lens.

Throughout all of my field work I have adhered to this type of direct view finders and have found them reliable.

My greatest difficulty in all of my telephoto work, from the beginning to the present, has been in my inability to secure a focus quickly enough.

As a concrete illustration, take a robin running along the ground towards the camera. He is there one instant and here the next and by the time the revolving turret of my B & H Camera is worked and a focus secured, the robin has so changed his position that a new focus is needed.

In 1917 I took up the study of big game photography, but as the telephoto principles and requirements are practically the same with these larger animals as for birds, except not so exacting with the former subjects, I will confine my illustrations to birds.

About 1918, I secured an Akeley camera, which I expected to be a great help in much of my wild life work by reason of the several well known inherent advantages that this camera has for the exacting field work I was doing.

I had all of my telephoto lenses made interchangeable for use with both my Bell & Howell and my Akeley cameras.

There is one device I had the Akeley Co. make specially for me, a description of which may interest you; as its object was the quick focusing of telephoto lenses. The device consisted of a metal box that fitted into the slots on the Akeley camera for holding the paired standard lenses. To the front of this box each telephoto lens was screwed. The box contained a right angle prism, by means of which, by pulling a lever, the prism is thrown between the film and the taking lens. In this way, the prism picks up the lens image and carries it to a ground glass on the end of the box, where the image is magnified by a small magnifier close to the ground glass.

By this method, it is possible for me to secure a quick and accurate focus, merely by pulling the prism lever at any instant desired. The scheme proved efficient and seems a long step in advance towards securing my much needed ability to focus quickly. This device, it seems to me, is to the moving picture camera what the reflecting mirror is to the reflex still camera. It does it work with equal relative speed and accuracy, as is demonstrated by my pictures.

In my blind work, I found it difficult to focus at the end of the prism box, so I eventually added a second right angle prism in front of the ground glass and thus brought the image to the rear of the camera, where, by means of a Goerz 8 times magnifying telescope, I can do all my focusing without moving from my operating position. I am still using this system and so far have found nothing to surpass it. There is but one other matter of which I will speak before closing. It is the use of sun shades in all telephoto work. I regard this as extremely important, and I invariably use sun shades with all my telephoto lenses. I line the inside of my sunshades with black velvet, having the pile of the velvet pointing towards the light. In this way, the maximum amount of reflected light is absorbed by the velvet, which is the most efficient medium I have found for this purpose.

To apply the velvet to the sun shade tubing, I use silicate of soda or water glass, which I believe is better for the purpose than shellac.

In this paper I have not tried to cover all points pertaining to cinematographic telephoto work, but merely those questions which I thought would interest you the most.

DISCUSSION

Mr. Fritts: This paper is of particular interest to me because in the last year I have had occasion to develop some equipment very similar to that used by Mr. McClintock. I notice that he goes to considerable trouble to hand crank his camera. I wonder if he has looked into the possibility of automatic drives, such as a spring motor?

Mr. McClintock: I have thought of this but it is often with me a question of keeping down the weight. A spring drive is not weighty, of course, but an electric motor would be. The hardest work I ever did was to photograph wild moose in the Rockies, and the guide and myself would lug the Bell and Howell equipment along and take it up to high altitudes. We would put it on our backs and lug it around all day, stalking moose as a man would with a gun.

At high altitudes when you are not accustomed to it, you don't add to the weight if you can help it.

Dr. Mees: A point that does not seem to be entirely realized by the designers of long focus cinematograph lenses is that the narrow field makes the optical problem different from that in still photography, where the size of field is very considerable. When dealing with very narrow fields, all the aberrations except central spherical aberration are relatively unimportant, and it is possible to correct spherical aberrations with a simple system. With long focus lenses, there is no need to use the elaborate systems normally adopted, and a simple one can take their place with a saving in cost and weight. The lenses must be well made, however.

With regard to focusing, the only method that appears to be promising for following a moving object is the range finder; that is a double viewing system in which the two images are kept in coincidence manually, this also operating the focus. This must be worked out for each camera.

Pres. Cook: I wonder if the suggestion of making telephoto lenses of simpler type is original with Dr. Mees.

Dr. Mees: Opticians know about it, but they have taken the regular camera lenses and used them on cinematograph cameras.

Mr. Rayton: The general thought suggested by Dr. Mees has been known to lens designers. I recall one article which appeared during the last year that sets forth the possibility. I presume one of the troubles is that the average user of lenses has tried nothing but the stock lenses which he finds on the market. His first thought would naturally be to try the ordinary telephoto lenses which he can buy without referring the matter to a lens manufacturer. If he did refer to a manufacturer the latter would be very apt to quote a pretty high price, because so far there has been a limited demand for such a lens. I think the demand is growing and such lenses will become available sooner or later, but it means a special correction. As Dr. Mees pointed out, field aberrations disappear but the lens must be corrected differently from a telescope objective in respect to chromatic aberration. If one is willing to carry bulk and weight, it would be possible to make a 17 inch lens working at a speed of f/3. It would be nearly 6 inches in diameter and would be composed of three or four components—at least three. This degree of complexity would be required for the correction of spherical aberration in a lens of such speed.

THE SUPERVISOR OF PROJECTION.

F. H. Richardson.*

IN ALL the realm of the entire motion picture industry, I know of no one thing so urgently in need of careful, intelligent attention, and what might be termed revolutionary action, as is the position or office of Supervisor of Projection.

The writer has many times, in print and by word of mouth, directed attention to the utter inefficiency of procedure as heretofore and now applied to the supervision of projection in theater chains. That this has had some measure of effect seems apparent, but there still is need for what may rightly only be termed drastic action concerning supervisors of projection, their duties, the authority vested in them, and the manner of their functioning.

So far as the writer has been able to observe, there has never been a real supervisor of projection in any of the large theater chains in either this country or Canada, although many men have held the title. The title has been largely an empty one, however, because little or no real authority has been vested in the holder thereof, and such authority as was conferred was subject to nullification, either wholly or in part, by theater managers or others in the organization, none of whom had any expert knowledge of projection matters.

The foregoing is not said with any intent of unkind criticism. It is wholly and solely a statement of known fact. It has been set forth in plain words to the end that those who read may consider whether or not such procedure is likely to result in efficient service, or is right and proper under conditions as they exist today.

In the beginning, it is true, projection was a rather simple matter. Projection equipment consisted of a single, very simple mechanism, an electric arc which seldom or never exceeded 25 amperes, a small rheostat and a rewinder. That was all there was in the way of equipment. Today the equipment is complicated, elaborate and quite costly. In the early days of the industry a shaky, shadowy, dimly illuminated, jumpy picture was all any audience expected. The admission price was 5 cents in most theaters, only the very "Ritzy" show shops rising to the dizzy height of 10 cents.

* Moving Picture World, New York City.

Today the prices range from a minimum of 10 cents to as high as $2.50. Audiences expect a clear, sharp, brilliant, rock-steady picture. They have the right to expect all that and they do. The projection of such a picture means careful, painstaking work by men of real ability. It means that unless the costly equipment is to deteriorate rapidly and need frequent costly replacement, it must be handled intelligently and carefully by men who know their business thoroughly and well. Times and methods have changed, and the 'hit-or-miss' sloppy methods of yesteryear no longer have a place in projection practice. Motion picture projection of today calls for modern methods, up-to-date procedure and the application of expert knowledge and skill.

There are today many theater chains of large size, and many more of considerable magnitude. The theaters owned or controlled by some of the chains have passed the half-hundred mark and since efficiency and excellence in projection have much to do with the success of each theater in the chain, therefore with the chain as a whole it would seem only a matter of common-sense procedure that projection matters in the chain be made a separate and distinct department of the organization, and that the department thus formed be placed in complete charge of the very best man it is possible to obtain, in return for a real salary. I say a 'real salary' because it is only by paying enough to make the position attractive that really high-grade men can be attracted.

This has in no case the writer knows of or has ever heard of been done. Men of fair ability, who under proper conditions might have developed into very competent supervisors, have in some cases been appointed, only to be utterly discouraged by the impossibility of accomplishing anything without adequate authority, hence the evident futility of trying to develop the position in such a way that its large worth would be apparent, and the salary therefore raised to a decent figure.

Other men of next to no ability at all have secured such positions and, amazing as it seems, have held them for years. By 'next to no ability' it is meant that these men had absolutely no knowledge of or training in the technical side of motion picture projection. They were not supervisors in any right sense of the word. They were really nothing more than 'trouble shooters,' whose chief duty was to be at the beck and call of the managers of the various theaters of the chain when some projection trouble developed which the projectionist should have been able to handle but was not. They were little more than a sort of glorified repair man. They exercised no real authority over the projectionist, that being vested in the theater manager himself. They had little or no real authority as to the selection of projection equipment, or anything else.

The purpose of this paper is two-fold. First, to point out the foolishness of procedure relative to supervisors of projection as it has heretofore been and is now practised. Second, to set forth the writer's views as to what the office or position of Supervisor of Projection in large theater chains ought to be, and the sort of man who ought to occupy it.

In the first place it is very necessary that those in position of high authority in theater chains alter what now seems to be their viewpoint. They must cease to view the position of Supervisor of Projection as a relatively unimportant one which may be filled by almost any man who is well versed in practical projection. They must cease to regard the Supervisor of Projection as merely a man to run out to the various theaters and straighten out mechanical or electric trouble in the projection equipment, because so long as that view is held, there will be no Supervisor of Projection in any right meaning of the term.

Rightly handled, the position is a really big one. For maximum results, it must be filled by a man of energy, character and high mental ability, who knows motion picture projection thoroughly, both in its practice and in the theory. He should also know how to handle men.

First of all, it is necessary to seek for and find such men, and they are very scarce, largely because of the fact that there has been slight inducement for men of ability who are versed in projection, to equip themselves to fill positions which have not, up to this time, existed.

Having found the man—and there are a few of them available—the first step would be to offer him a salary—not 'wages,' mind you, but a real SALARY of sufficient size to cause him to want the position and to work hard to deliver the goods, and thus to hold the position once he has it. In other words, a remuneration which will bring out the very best there is in the man.

The next step, and one which would, I fear, come even harder than the first, would be to invest him with real authority over all projection matters. Of course, it is not meant by this that the theater manager should be deprived of all authority over the projection in the theater he has charge of. That would be impossible, but as matters now are, the theater manager, who usually has practically complete authority over projection, more often than not knows little or nothing about the thing concerning which he presumes to issue instructions. Naturally the result is not the best. He should not be permitted this authority without a very definite bridle, and the bridle I propose is that he must, in all matters save the speed of projection, issue his orders to the projectionist through the Supervisor of Projection. It might also be wise to oblige him to consult the Supervisor if he wishes to exceed a certain maximum speed of projection. No possible harm could come from this procedure and if the right man is Supervisor, the result would be beneficial in many ways.

Such a proposal is, of course, little short of revolutionary, but things now are in such a state that nothing short of revolutionary methods will suffice. It surely will be conceded that it is at least not wise to place so important a matter as projection at the mercy of the orders of a man who has no expert knowledge of it, or of its requirements, and certainly the average theater manager does lack such expert knowledge.

I have told you my views as to salary and authority, and have indicated the sort of man I believe to be needed for such a position. I now will tell you what, in my opinion, the duties of the Supervisor of Projection should be.

First of all it would be his duty to call all projectionists together, so far as location of the theaters permit, at regular intervals, talk to them on such subjects as might seem best and have them addressed by experts on the care and handling of equipment. Also manufacturers of new equipment should be invited to attend the meeting and demonstrate the new goods.

He should compile and issue a monthly bulletin in which the news of the circuit would be printed, and in it those men who have shown superior results, or a progressive spirit, or anything deserving commendation, would receive it.

Foolishness, do you say? Not so, though at first glance men may be inclined to doubt or even ridicule the proposal. It is a recognized fact, however, that worth-while men will work very hard to secure public commendation and to have it publicly known that they have excelled in work, or in anything else. The plan really amounts to the setting up of a friendly rivalry among the men, and the development of a company spirit.

It would be the duty of the Supervisor to require each Chief Projectionist to make a monthly report of all supplies on hand, and the exact condition of every part of all equipment, carefully prepared blanks being supplied for the purpose. With such reports at hand, he very soon would be able to maintain a certain definite stock of spare parts and supplies in each projection room, and to order equipment repairs and replacements before trouble, through excessive wear, developed.

It would be his duty to equip a small laboratory in which tests of new equipment devices, lenses, etc., could be made, and the relative results from various types of equipment determined with at least very close accuracy.

It would be his duty to receive all complaints made by theater managers concerning faults found with the projectionist, and to deal with them as seems best under the circumstances, the right to suspend or to discharge resting entirely in his hands.

It would be his duty to receive all complaints of emergency equipment or electrical trouble, and to send a man to straighten matters out.

It would be his duty to make periodical, unexpected visits to every theater in the chain, watch a show, if possible without the projectionist having knowledge of his presence, and to make careful inspection of the projection equipment, comparing what he finds with the last report made by the Chief Projectionist.

It would be his duty to check over all plans for new theaters, and to make suggestions to the architect concerning such things as seem likely to operate to the detriment of projection.

It would be his duty to grade the theaters and men, and to evolve a plan of giving the most desirable positions to those men who showed the most consistently good results and the most progressive spirit, each time printing in the bulletin before suggested, his reasons in full for selecting the man for the job.

He should, as a part of his duty, make periodical reports to the head of the organization concerning the exact condition of the equipment in each theater, and such recommendations as he may think right and proper for the replacement of worn equipment, or for making a change from one type of equipment to another.

I have been unable to do more than give you a general outline of the matter, without going deeply into details. The working out of details is something, which in any event, practice must finally determine. That the general ideas I have advanced are sound I hope and believe you will all agree. The method in which theater chain projection matters have been handled in the past has bordered upon the absurd, not to say ridiculous. The methods pursued have worked inestimable harm. There has been enormous waste in equipment, in electric energy, and the injury to the screen results has cost box offices many, many times, in loss of revenue, what the added cost of procedure along the lines I have suggested, or somewhat similar lines at any rate, would amount to.

DISCUSSION

Mr. Edwards: The paper deals with a subject of considerable importance to the Society. The majority of the members are engaged in trying to find the best methods of producing results on the screen and certainly an efficient Supervisor of Projection in the theater will be of the greatest value in that regard. As Mr. Richardson remarks, the matter of the Supervisor of Projection up to date has been little short of a joke in many cases. In a great many instances the careful investigations made in the laboratory and in the different shops for the producing of material for use in the projection room have been largely nullified by the utter lack of co-operation on the part of the management. I think an efficient Supervisor of Projection would form an important liaison between theater owner, manager, projectionists, and other interested personnel of the theater proper. Unfortunately some of Mr. Richardson's recommendations seem a little revolutionary if we consider the practice today. Up to the present, projection needs have been dominated not so much by the individual manager, as by the purchasing agent of the concern. The projectionist makes a recommendation to get a given piece of apparatus to give a certain effect in the theater. The purchasing agent finds that it costs $50 more than he thought it would and the purchase is shelved only too often. If it were possible for a chief projectionist or a Supervisor of Projection to have some say in the purchase of necessary projection supplies, it would be a godsend, not only to the industry as a whole but also to the Society, because you would have a chance to see your recommendations put into practical use in the theater.

One of Mr. Richardson's recommendations has, in a general way, been tried out with great success by the American Projection Society; that is, the getting together of the men in the projection end of the business and spending a certain amount of time each month on lectures, demonstrations of apparatus and so forth. This has been found of great benefit. One of the most notable lectures in that series was given by Mr. P. R. Bassett on the "High Intensity Arc." You would be surprised to know how much misinformation is given projectionists by salesmen and others. Mr. Bassett was able to clear up many misunderstandings for a large number of men in New York City, and I think that, if that practice could be carried out in the individual circuits, you would see a great improvement not only in the material for the use of the projectionist, but also in the manner of handling that material, which would be highly beneficial to the industry.

RECENT ACCESSIONS TO THE SOCIETY

Barrows, Thad C. (*A*).
Metropolitan Theater, Boston, Mass.
Burchett, C. W. (*A*).
255 Golden Gate Ave., San Francisco, Calif.
Coffman, Joe W. (*A*).
350 Madison Ave., N. Y. C.
Cohen, Emanuel (*M*).
145 W. 55th St., N. Y. C.
Jones, John M. (*A*).
433 Beaumont Ave., Charlotte, N. C.
Mitchell, H. Fawn (*A*).
5729 Ridge Ave., Chicago, Ill.
Murray, W. W. (*A*).
528 Madison Ave., Scranton, Pa.
O'Brien, Morton D. (*A*).
Loew's Inc., 1540 Broadway, N.Y.C.
Owens, Freeman H. (*A*).
70 Lafayette St., N. Y. C.
Phillimore, Chas. E. (*A*).
Bell & Howell Co., 1801 Larchmont Ave., Chicago, Ill.
Rayton, W. B. (*M*).
Bausch & Lomb Optical Co., Rochester, N. Y.
Rommell, F. J. (*A*).
206 Schmidt Bldg., Cincinnati, Ohio.
Rubin, Harry (*A*).
Rialto Theater, Broadway and 42nd St., N. Y. C.
Samuels, Irving (*A*).
Hunsicker Bldg., Allentown, Pa.
Tamlin, B. G. (*A*).
Jeffery Laboratory, 9 Giles St., Rose Park, South Australia.

CHANGES OF ADDRESS

Bradshaw, A. E. (*A*).
610 South M St., Tacoma, Washington.

La Rue, Mervin W. (*A*).
c/o Bell & Howell Co., 1801 Larchmont Ave., Chicago, Ill.
Rabbell, Wm. H. (*M*).
2647 West Philadelphia Ave., Detroit, Mich.
Ruben, Max (*A*).
c/o Sullivan's Theater Ticket Service Co., 728 Seventh Ave., N.Y.C.
Struble, Cornelius D. (*M*).
624 So. Michigan Ave., Chicago, Ill.

CORRECTIONS IN LIST OF MEMBERS

Barleben, Warl A., should read Karl A.
Handschlegel, should read Handschiegl.
Loewe, should read Loew.
Wallaston, should read Wollaston.

FILM IN GOOD CONDITION FOR ALL THEATERS.

TREVOR FAULKNER.*

FILM distributing organizations are making an effort to keep film in good condition in its passage from theater to theater. Nevertheless, by the time it reaches the smaller houses its state of preservation may be exceedingly poor, a fact which cannot but prejudice the entertainment value.

The first step in remedial measures must be to decide what defects shall be styled 'poor condition.'

My own opinion is that disturbed continuity is the worst defect, and the one which is prevalent in theaters farthest removed from the first run. The second is scratched film. Like the first, it is pernicious because when it has once occurred it cannot be remedied. Then in order come improper splices, weakened perforations, objectionable end signals and dirt and oil.

Let us consider *disturbed continuity*. In past years the censor boards in different states have each insisted on their own eliminations, and have often removed portions which they have failed to restore as the film passes on its journey. Now, fortunately, the producer is taking such care that the censors do not intervene.

The projectionist may be guilty in two ways. He may forget to replace film omitted to shorten the program; and he may purposely conceal omissions due to accidents. The remedy lies with himself.

The nuisance of bad splicing requires ventilating. The faulty splice is objectionable not only because it means breaks in the machine and because another frame must be cut out in repairing, but because a poor splice may cause the sprocket teeth to skip and ruin quite a length of film. To state the trouble is to state the remedy.

Scratched film is due almost entirely to carelessness, not only by the projectionist, but in the exchange. Film gets scratched not only by going back to the exchange but *because* it is going back. The projectionist who has film for an important run of some weeks treats it with scrupulous care to maintain it in condition for his own use. It is film circulating from theater to theater on short runs that get in such appalling condition. Every few days it changes hands and the responsibility for its condition becomes shifted. The kind of carelessness which causes damage is allowing the rollers in the

* Famous Players-Lasky Corp.

magazine trip to become stilled or clogged with dirt and broken film. Projectionists forget to adjust the tension or let the aperture wear and become covered with baked emulsion. They use change-over signals and automatic rewinding devices carelessly. Personal care can eliminate damage from these causes, and personal care is the only remedy.

However, it is unfortunately true that damage also occurs in the inspection rooms at the exchanges. The habit of allowing the film to slide under the palm of the gloved hand is responsible for long continuous scratches whenever a piece of dirt gets lodged in the fabric. Another crime habitually committed is the tightening of loosely wound reels. Its effects are the most fatal if the film has previously been spilled on the floor.

Now we come to bad splicing. The only useful advice to people who make poor splices is the advice given by Mr. Punch to those about to marry—don't. In fact, this simple admonition 'don't,' applied to careless procedure would cure almost all the ills to which film is heir.

However, men and machines being what they are, it behooves us to evolve some systematized remedy. This must consist in the establishment of rules so well advertised and so self-evident in their importance that they will be obeyed.

To the projectionist we would say:

Avoid oil in the wrong place—be clean;
Replace worn sprocket wheels;
Adjust gate tension and keep the gate clean;
Make careful splices;
Notify the exchange of loss of continuity and other accidental damage;
Treat the film as though you were the only user.

To the exchange the directions would be:

See that the film is sent out in good condition;
Scrap ruthlessly over-worn and damaged stock.

When these rules are obeyed, and only then, will the millennium of "film in good condition for all theaters" be reached.

THE BUSINESS OF INTERNATIONAL NEWS BY MOTION PICTURES.

Emanuel Cohen.*

SIXTEEN YEARS ago a new industry was established in America—the dissemination of world news through the medium of motion pictures. The evolution of news recording has kept pace with the progress of civilization, for, in a large measure, such progress is dependent upon intercommunication between the different peoples of the world. From its lowly beginning of symbol carving in stone, through the hieroglyphic stage, the ancient papyrus, this business of news dissemination has in the last few years developed a new medium—the motion picture—so that not only can the people of one country be told of the activities and achievements of their fellow men in distant lands, but also they can actually see these activities and accomplishments.

When, in the early nineties, the new art of the motion picture was developed, mainly due to the inspiring genius of one of America's great inventors, Mr. Thomas Edison, its purpose and scope was conceived largely for the entertainment of the masses. Here and there, at that time, the pioneers of the industry went beyond this scope and directed their lenses on some news events—but only in a sporadic fashion—an occasional glimpse of new possibilities. It was in 1910 that there came the fuller realization of this newly discovered but unexplored field of motion picture usefulness, when Charles Pathé presented for the first time a regular and systematic medium of news dissemination by films. Public recognition of this usefulness has steadily increased, and I, personally, in my twelve years of editorship of the Pathé News, have had the opportunity of seeing the news film grow from a mere exhibition in a few hundred scattered theaters, where it was used mainly as a filler on the program, down to the present day, where the combined circulation of all news films reaches almost 90 per cent of the 18,000 motion picture theaters in the United States alone. It is conservatively estimated that the news film is now seen by forty millions of people a week. Also, we find it now, not merely a filler, but a vital part of the program, an institution recognized by theater and public alike, as playing an important role in news communication and in the life of the nation.

* Editor-in-Chief, Pathé News.

Like the great news syndicates, the Associated Press, the United Press, International News, of whose tremendous service the public is so fully aware, the news weekly is now world wide, its tentacles reaching into every nook and corner of the earth—civilized and uncivilized—its thousands of lenses focussed on every political development, witnessing the pageantry and the tragedy of every people; peering into the customs and habits of every land; holding the mirror to every phase of human activity everywhere.

Although its purpose is similar to that of the newspaper, the news film plays a different role. Its objective is to bring its readers to the very scene of an event, making them eye-witnesses, so that they not only see what transpires but can feel its pulse. The deadly accuracy and the vivid realism of the news film has brought it to the heights of purpose and utility which it now occupies. It has reeled its way into the confidence of millions of persons. Supplementing the service of the country's great newspapers, this graphic portrayal is enabling the public to form clearer judgments of world events and guiding it to more intelligent understanding. The excursion round the world on which it takes its readers in the 15 minutes of each issue, as if on the wings of time, has made it possible for them to see and to become acquainted with other lands. The lions of Trafalgar Square are just as familiar to American audiences as the Woolworth Building to the Englishman. The sufferings of Japan in the tragic hours following the earthquake were felt from the screens of the globe. The remarkable achievement of America's Round-the-World Fliers was witnessed in every hamlet.

In this article I shall take up first the business of getting the news and later the value of the motion picture news medium in the progress of the world.

Getting the News.

Daily great newspapers mobilize veritable armies to do battle with the complicated task of catching events on the fly. With hundreds of telegraphic nerve centers covering the world, great press associations never dare sleep in the keen vigil imposed on them by the ceaseless activity of nations. The problems they solve in putting your daily newspaper into your hands are varied, intricate, never ceasing, and yet with the newspapers, two men at the ends of a wire represent in simplest form all that is needed for news transportation across the world. How different the animated newspaper that tells its story with motion pictures. With the news reel, too, all must be subordinated to the law of speed, but it deals in a physical medium and must be gathered and carried by human machines, that cannot ride on an electric current.

The news weeklies maintain in all important centers of the world their own staff of cameramen. These men are stationed at points where from experience, which has become akin to instinct, news is likely to happen and they are moved about from point to point as the editorial staff follows the broad movement in news happenings. These men are in daily contact with headquarters reporting impending events in their territories so that we learn of them as readily as the news syndicate. The editorial staff in turn refers back to each territory the results of any studies that it may make in digesting news happenings throughout the world. At points where news is less likely to happen, there are a horde of semi-staff men, who, although not required to devote their full time to news work, still are ever on the alert. Then again at points where news is still less likely to happen, we have thousands of correspondents or cameramen, who contribute on space rates, pictures of events in their territories.

There are as many good definitions of 'news' as there have been great editors to present that indefinable commodity to an ever eager public. Yet news has one quality that governs the activities of all who lead strenuous lives in "getting the story and getting it home." News is news only when new to the world, when it can still thrill, excite, arouse with all the warmth of fresh sensation, when it is red hot from the forge of events.

At this point I may point out that there are three types of news. First, sudden news events like the Japanese earthquake, the Santa Barbara earthquake, or the Shenandoah disaster. These events happen suddenly out of a clear sky, you might say, and with no forewarning.

A recent example of this type of news is the great disaster in Florida, which took the tragic toll of hundreds of lives and devastated a vast area of America's winter playground. One of our cameramen was on the spot. Injured himself, as were thousands of others by falling walls, he nevertheless stuck to his camera and ground out foot after foot of film as the 120-mile wind swept all around him. That was not all. It was necessary to show the public the graphic story of this event as quickly as possible. He therefore walked miles with his film and then took an automobile to get to the nearest point from which a railway train could be boarded, out of the stricken area, and succeeded in getting to Jacksonville within 24 hours after the hurricane occurred.

At Jacksonville he was met by an airplane which had been engaged, and transported to Atlanta where a second airplane was being held in readiness to transport him to Charlotte. The cameraman had to be physically carried from one plane to another with his precious films in his hands and which he insisted on delivering personally to headquarters. The plane from Atlanta was forced down by a terrific rain storm near Greenville, South Carolina, from where the cameraman then made a hurried trip by automobile to catch a fast train that took him to Washington. He was met there by another airplane which transported him to New York, thus bringing the first pictures of this terrible event to the screen within 48 hours.

Second, there is the field of impending events, which refers to those happenings which occur as a natural result of preceding events. A most notable example of this was the Smyrna fire, resulting from the war between the Turks and the Greeks in 1922. One could not foretell that the Smyrna fire would result, but by keeping close to the news scent of the situation it was apparent that some tragic occurrence was at least very likely, in one form or another. We were fortunate in this particular instance, for not even the newspapers kept their reporters in the zone of military operations so that as a result of our judgment in this field of impending events, we obtained an exclusive picture of such a tremendous event.

Third, we have the scheduled events. Events which are scheduled to take place on a certain day, such as the inauguration of a President, the World Series, or the Yale-Harvard football game.

To produce successfully a great news reel that insists on the entire world as its stage is to be above all else a good judge of men, to be able to find unerringly the hundreds of right individuals who can be trusted not to quit on the job when the job gets lively, and to build up in these men, scattered to the four quarters of the globe, the personal co-operation, the unfailing esprit-de-corps that a great organization, functioning always at high pressure in a widely diversified and hazardous field, must have before all else if it is to cheat time and unlucky chance at every turn—which it must do to bring home first pictures.

Very often I am asked how we are able to get men to the scenes of action in every part of the globe. People wonder as they sit in the theater how we could possibly have reached the scene of an accident in time to obtain a picture. In answer, I may say that in some instances it is by pure accident—the luck of a reporter, who may be walking down the main street very nonchalantly when he sees a building collapse. But in the main it is the result of such a tremendous organization circling the globe, ever on the alert, of careful study and preparation and quick transportation of men and film that makes it possible for us to obtain these pictures.

Transportation Methods.

As stated before, the motion picture news still deals in a physical medium. It cannot be wired or phoned. The cameraman must physically transport his outfit from his base to the scene of action. He must get within range of that action. He cannot depend upon hearsay. After the picture is made, he must actually ship it to his headquarters. Special trains, boats, airplanes, the quickest means of conveyance always to the scene of events must be used and then back to headquarters. A careful study and special men trained in the ways and means of quick transportation in all parts of the world are vital parts of a news reel organization. The Smyrna fire film, for instance, was received in New York and released exactly 14 days after the fire took place, 8000 miles away. This was the result of a special boat chartered for a trip to Italy, where a plane, engaged in advance, was waiting to transport the film to Cherbourg to meet a trans-Atlantic liner. Or in cases of events occurring nearer home, the Santa Barbara earthquake, the inauguration of President Coolidge, the burial of the Unknown Soldier, the World Series, the Shenandoah disaster, the S-51 that sank near New London, or other events, the films were transported by special airplane, with a moment's preparation, to our various laboratory zones. Then again, after the pictures are obtained through such expeditious efforts, there is still the problem of getting them to the theaters so that the public may see this news while it is still hot. In all of these instances, and many more, the prints were shipped from the laboratory zones to the theaters throughout the country so that they arrived, in many instances, from 24 to 48 hours after the event. The Santa Barbara earthquake, for instance, was shown in Los Angeles and San Francisco the same day; in Seattle, Salt Lake City, Denver, Kansas City, and Omaha the next day; and then the following day in Chicago New York, Pittsburgh, Philadelphia, etc.

World Import of News Film.

Now taking up the value and influence of the motion picture news medium in the life of the world. Am I presuming when I refer to what the news film has accomplished and has the power still to accomplish in the way of fostering that understanding and amity between the peoples which statesmen are so eagerly striving for, as the basis for international good will and tolerance? The news pictures are within the grasp of every individual. All peoples, irrespective of thought, race, or creed, find instantaneous expression and common understanding in the news film.

At a dinner held in New York recently in celebration of the fifteenth anniversary of the establishment of news dissemination by motion pictures, a reel of the most important events during these 15 years was flashed on the screen.

The great poet who sighed in hopelessness, "O, God, turn back the universe and give me yesterday," had never seen a news film. In this film the universe was turned back and yesterday seen.

The value of the news film was written on the minds of the audience forever, after they traveled back over the years with the news reel. They saw the world before the great war. They viewed the personalities of the world's greatest men who have passed into the Great Beyond. They witnessed epoch-making events, some of which have changed the map of the world. When these pictures were taken they were just simple matters. Now, after surviving the whirlwind of the world's changes, they have a new significance which makes them the stage centers of the most gripping drama ever known.

Just suppose we had had cameramen at Valley Forge! And we could sit here and watch Washington and his freezing army of ragged patriots starving and bleeding for the wealth and freedom which we are enjoying today. One hundred years from now our descendants will feel the horror of the Great War and the undying heroism of all who fought in it. Suppose we had had the news film at Bunker Hill! At Lexington! At Yorktown! What an imperishable history for us! Can you imagine being able to witness John Hancock signing the Declaration of Independence or Abraham Lincoln signing the Emancipation Act? It would impress you, would it not? Even if we could witness our beloved Theodore Roosevelt thundering up San Juan Hill, we might feel as though we were being gifted by Providence with unearthly sight. Since 1910, however, such events have been recorded for posterity. The news film has come to be the greatest historian of all. Our Presidents, our soldiers, and our public men from now on will live forever. When our grandchildren read in their histories of some great political movement, some bitter struggles, some great victory won, they will look up from the printed word, and see as real as in living flesh the men who did these things. How much better they will be able to understand! And as we viewed this film, "Flashes of the Past," it made us wonder what the "Flashes of the Future" will be—what Destiny will inscribe on the celluloid pages of history. As the progress of human events marches on, perhaps this very method of news recording will itself be further perfected so as to be of still greater service to the public. Time and space in the transportation of films will be reduced and minimized. Who can foretell but that in our own lifetime we will see the day when motion pictures will be transmitted by the ethereal waves of the radio, so that the public will be able to sit in its favorite theater and watch the pictures of events throughout the world even as they are transpiring, when the whole world will be linked together in instantaneous understanding.

An early experiment.—In a report of a meeting of the Photographic Society of Great Britain, now the Royal Photographic Society, it is stated that Mr. Friese-Greene exhibited an optical lantern appliance, devised by Mr. Roger of Bath. It consisted of a lantern condenser, the tube facing which was divided longitudinally into four sections by opaque diaphragms. In front of the four tunnels so made, were four small object glasses, with a rotating diaphragm in front. Four portraits of one sitter, with a different expression of countenance in each, were put into this arrangement, and by the rotating diaphragm permitting one lens to act after the other, the eyes of the portrait were seen to apparently move upon the screen, and the expression of the countenance to change; in fact, said Mr. Greene, the very skin of the face could be seen to move. . . . . He demonstrated all this upon the screen with the aid of the lantern, and the effects excited much interest. (Brit. J. Phot. 1886, *33*, 71).

INSTRUCTION IN MOTION PICTURE PHOTOGRAPHY.

Carl Louis Gregory.*

MOTION PICTURE instruction has only a brief history to relate at best and it is because no coherent and comprehensive plan for training students in the technical branches of motion picture production is yet in existence that this paper is presented.

During the World War the army trained men for the work of making historical and medical records in motion picture form but the instruction was confined to the schooling of an already experienced personnel for military purposes only. Extension courses in the technique of motion picture production were given at Columbia University for a few terms but the funds to pay competent instructors were inadequate.

Various motion picture companies have from time to time announced their intention of establishing schools for the training of students in the technique of picture production but their motive was the acquirement of free publicity rather than any constructive contribution to technology. Instruction in motion picture technology is perhaps a better title than the one I have chosen since adequate instruction in motion photography is only possible in conjunction with the other crafts and professions which contribute to the production of film.

Every other industry demands and receives an unending supply of trained men from the technical schools and colleges of our country while the motion picture industry must train their own in the haphazard school of experience or filch their employees from other companies by paying them higher salaries.

Some of the larger corporations such as Famous Players do maintain a sort of apprenticeship school for cameramen and other technical workers, but no systematized schedule of instruction is maintained. This has no reference to the Paramount School of Acting although such a training school would seem to be a natural corollary to any thorough course in the technology of picture production. It is time for the producing heads of the great companies to awaken and provide a means whereby future cinema technicians can obtain the proper schooling in the arts and crafts of the motion

* Dean, New York Institute of Photography.

picture. Surely the industry is big enough and rich enough to endow colleges of Motion Picture Technology at some large university in New York and in Los Angeles.

The industry could not fail to benefit by the infusion of academic blood thus obtained and who knows but what the Universities might benefit also from the freshness of the new studies in their curriculum?

The Motion Picture Producers and Distributors of America could scarcely find a better method of demonstrating a reason for their existence than to provide the endowment needed to establish a college or colleges of this nature.

An endowment for schools of Motion Picture Technology would be in the nature of an investment which in a few years would pay tremendous dividends to the industry by providing the studios with technically trained men properly fitted for the positions for which they are employed.

The appalling amount of waste that occurs in the production of pictures is due largely to incompetence on the part of employees. Better training of the employed personnel would reduce tremendously the exorbitant waste that today seems unavoidable in the studios.

Systematic training would give a coherence to the industry which it has not hitherto achieved. It would be an extension of the idea which brought the Society of Motion Picture Engineers into being. It would provide for the accomplishment of research work for which the individual studios have neither the inclination nor the facilities.

Such an institution could also centralize and co-ordinate the work of producing films for instructional purposes in schools and colleges. Up to the present time the making of instructional films has been a commercial affair often contaminated by advertising matter or other extraneous propaganda. They had to be made primarily to pay dividends to the maker before the instructional value could be considered.

The problem of making really useful educational films is quite different from that of publishing text books. A market of huge proportions awaits the publication of any good text books. A text book can be written in the spare moments of the time of even a busy man with an insignificant expenditure for paper and ink. The manner of presentation of the subject is along well known and recognized methods of principles. The presentation of an educational subject in a motion picture film is quite another matter. There are no well established principles to furnish a blue print for the making, no recognized and familiar guide posts to show the way.

The man who wishes to make an instructional film must learn new and intricate profession in order to transfer his ideas adequately to celluloid. It may be said that he has only to employ a photographer to do this work for him. That is not so. It is rarely that the training of the scholar and the photographer can so combine that the result will be better and not worse than the conception of the creator of the sequence of instructive pictures. Besides this the cost of the necessary apparatus and the photographer's time are usually prohibitive.

An endowed College of Motion Picture Technology with its studios, apparatus and laboratories would furnish the creator of instructional films with a medium of expression. Through its faculty the educational picture material already in existence could be co-ordinated, supplemented and edited into a comprehensive series covering all the subjects that can be aided by visual instruction.

With a dependable source, supplying complete programmes of educational subjects, visual education would expand and increase to unimagined proportions.

Sub-standard film has solved the problem of cost and eliminated the fire hazard which were serious drawbacks for small classes and remote schools.

There is already in existence, as a branch of university extension teaching, an exchange system for the distribution of Visual Education Material. No doubt this system is capable of indefinite expansion and extension.

Were a college of Motion Picture Technology to be established prospective students would swarm to it like beauty contest winners migrate to Hollywood. Through processes of elimination now in use by many of the schools and universities only the most promising material would be allowed to matriculate. Thus the studios would have a choice of picked personnel thoroughly trained for their work.

Men whose experience in the studios fit them for the work of lecturing and instruction in the college could be loaned for short periods to supplement the regular members of the faculty. By a rotating system of visiting experts a continual fountainhead of new knowledge and practice would flow to the students in training.

Endowing a Motion Picture College in an already established university, let us say Columbia University by way of concrete example, presents many advantages. Those subjects upon which technology is founded—Physics, Chemistry and Engineering—are already established with their laboratories, their faculty, their efficient organization. Only the specialized and advanced subjects in ciné work have to be installed. The foundation is already firmly laid. It needs only the concerted interest of a few of the great men of the industry to make a college of Motion Picture Technology an accomplished fact.

DISCUSSION

Mr. Palmer: I feel that the motion picture industry is suffering every day because it has no training school for new men coming into the industry. Hardly a week passes by but what we have men come to us looking for positions in the company. Some of them we can see have ideas and are good potential material for our work, but because of the fact that they have had no experience, we cannot take them. If there was a school that these men could go to and get some preliminary training, I am sure that the personnel of the studios would be greatly benefited by such an arrangement.

Mr. Crabtree: I understand that Famous Players had a theater managers' training school and also a college of acting. Is it Mr. Gregory's idea that this university for motion pictures should include faculties of screen acting, theater managing, camera work, scenario writing, directing, and so on?

Mr. Gregory: All of the technical branches of the art.

Mr. Crabtree: I should like to ask Mr. Palmer what conclusion has been arrived at with regard particularly to the school of acting. Was it worth while?

Mr. Palmer: The school of acting was a success and has resulted in the company obtaining out of about twenty-four students who began the work about eight who are still with the company, and I think that most of these will continue and be known to the theater-going public in the course of a few years.

Mr. Brown: I can speak for the managers' school, which was a success. Of seventy-five men who entered in the first two classes, approximately sixty are now working for the company in all parts of the country—in theaters from San Francisco to Florida—perhaps fifteen as managers and the rest as assistant managers. All the rest are employed by other companies if for one reason or another the men were not willing to fit into the jobs offered to them with Famous

Players-Lasky. The school gathered together an immense fund of technical knowledge. Experts in every line from historical experts, such as Terry Ramsay of the Photo Play Magazine, to Mr. Hall who designed the new Paramount Theater, eagerly gave their time and lectured before the class, and other people would have been glad to come and were anxious to come and put their particular technical knowledge before us if it could in any way be twisted into anything benefiting a theater manager.

Mr. Rogers: There may be a little interest in the attitude of the colleges. I have taught motion picture work at Columbia in the University Extension Division. We parted on the basis that I said it was impractical to carry on unless we could have proper quarters and equipment to teach in a practical way. We wanted cameras, sets, stages, printing machines, laboratory, and so on. I said that I believed that men in the industry would provide these if the University would give the quarters adequate for the purpose to be devoted exclusively to the production. The University said: "It is interesting, but we have no room and want you to carry on as you have," but I declined. If some university such as Columbia or New York University will set aside proper quarters, I think men in the industry will see that equipment will be provided and a practical beginning can be made.

Prof. Wall: I can speak from a few years' experience teaching photography in college. When we opened the school I was swamped with applications from boys wanting to enter. The first thing the parents asked me was "What will my boy do when he gets through?" "How long will it take to teach him?" A great many more than 50 per cent of the applicants wanted to get through the complete motion picture course in 6 months. It is impossible to teach it in 6 months, and a man must have a good grounding in chemistry and physics before he can learn photography, and in motion picture photography it is even more difficult.

Mr. Palmer is perfectly correct. You cannot expect the large companies to take in raw material, because of the enormous waste they cause. If you establish a school of photography, you must lay down precise rules for the students and adhere to them. You must not admit a man because he cannot afford to pay the fees and turn out material utterly useless to the profession.

Mr. Gregory: I am very glad indeed to listen particularly to Mr. Rogers and Mr. Wall on account of their practical experience in instruction. I personally have had something to do with the training of over two thousand students in motion picture work. I was in charge of instruction of the Signal Corps at Columbia during the war, and I am at present connected with a commercial school teaching photography and motion picture work, and two vital points have already been dwelt on by Mr. Palmer and Mr. Wall, namely, the fact that there is a tremendous interest in the subject and, secondly, hopeless personnel must be eliminated. However, there is a considerable residue which would be of great value to the industry if they could have an opportunity to secure practical training.

The Harvard School of Business Administration has announced that a complete and detailed study of the motion picture industry will be conducted at the School. Messrs. Will Hayes, Adolph Zukor, Marcus Loew, Jesse Lasky, Cecil B. DeMille and Sidney R. Kent are to deliver lectures. Three reasons for the course are specified: the need of, and opportunity for, trained business men in the industry, the influence of films on daily life, and the fact that the industry has grown so rapidly that all stages of its development can be clearly traced.

THE FUTURE POLICY OF THE SOCIETY OF MOTION PICTURE ENGINEERS.

K. C. D. Hickman.*

AT NO period in a man's history is introspection and readjustment more necessary than in the transition stage from boyhood to maturity. What is true of the individual is not untrue of a collection of individuals working as one unit under the banner of a 'Society'. You will probably agree with me that our Society of Motion Picture Engineers is in some transition stage and will come to no harm if it indulges in a little self-inquiry.

It is with some diffidence that I, who have had no hand in your founding, who have scarcely labored in your cause, stand here to induce this process of psycho-analysis. Nevertheless, if we are to criticize ourselves, rather than that this criticism should come entirely from within or entirely from without, perhaps it is not unfitting that someone on the border line should be the critic.

By reference to the printed Transactions it can be seen that about 10 years ago some twenty men of whom, among others, we might mention Mr. Jenkins, Mr. Hubbard, Mr. Porter, Mr. Richardson, as with us now, instituted this Society, primarily with the object of securing mechanical standardization within the motion picture industry. You started with a small membership but in two years your numbers were doubled. You were born a healthy ten-pound baby and without ever decreasing in weight you grew to strong childhood putting on flesh nearly all the time until you have reached your present sturdy stature. But if we examine your health a little more closely we find that your weight (about 200 members) has been at this figure for 2 or 3 years. Have you in the nature of things stopped growing? Or are you being poorly nourished? For the next half hour I am presuming to pose as your family doctor diagnosing your symptoms and suggesting remedies. And since I have the honor now to be a fellow member I shall speak of *you* as *we*.

For a society to endure it must be both cohesive and magnetic. It must bind together those within and attract those without. Much cohesion can be provided by just common ordinary loyalty but this cannot provide attraction. To secure new members and even to keep old ones we must sell them something. In a world controlled by

* Research Laboratory, Eastman Kodak Co.

sale and barter a society cannot be knit together by sentiment alone. When each one of us joins the Motion Picture Engineers he has an axe to grind. I have; you have. Later the more vital forces of friendship, co-operation, and loyalty to a common cause begin to move us but at the start we come for what we can get. I support the Society because it affords me a means of securing information; because I can talk to the best technical men in the industry; because I enjoy our conventions; and now it is beginning to be because I look forward to meeting the friends I made at the last convention and because I am getting interested in our joint welfare. Perhaps some such thoughts and feelings animate you too.

Let us be honest then and say we need the Society because it is useful to us. Let us agree that the Society needs us because we are vital to its welfare. It must have our brains for its policy and our money for its food. And the more of each it has the better for its policy and its physical strength. To do our best for the Society our first consideration must be *more members.* To secure more members we must make the Society more valuable and of wider appeal. We must think of new things to sell to an extended clientele.

There must necessarily be a wide difference between the development of a learned society and one which is chiefly technical. A learned society deals with fundamentals; with facts and changing theories. It exists primarily for the discussion and publication of research work—work which will be extending to the end of time. Your technical society on the other hand deals with an *art,* and only with science as an aid to that art. There can never be the volume of research which arises from a purely scientific origin. The exponents of the art must always be as interested in established technique as in the latest developments. And in an established art those developments must be relatively slow.

The history of our own motion picture society runs parallel to that of a host of other technical societies and journals. At the outset there is a vast amount of material at hand. There is the entire art with its scientific basis to be written up; there is standardization to be accomplished, research work and future developments to be reviewed. This takes a few years, and because the knowledge is relatively new and its spread through the personnel of the industry is important, the Society waxes strong and flourishes. And then come the lean years. The harvest has been gathered, the reaping machinery is all intact, but there is no more corn. The Society is treating its parent industry much as the world treats its petroleum supplies. It is pumping up vast stores of material laid down in the past. A time will come when it will have to be content with a small amount being formed in each current year. But fortunately there is this difference between the petroleum supplies and a technical society, for whereas the former is pumped away never to return, the latter may rebury its knowledge and pump it up for the benefit of succeeding generations.

When you were very young do you remember going to your first musical comedy, how thrilled you were at the lights, the rhythm, the painted faces, and the whirl of bare legs? And then in middle age you have perhaps again drifted into just such a show, and instead of a thrill you have turned away with a yawn—What, have they nothing new in twenty years? But when you looked at your audience you saw eager faces, just as thrilled as you ever were. The show is the same but the generation is new: younger people to whom age-old truths (and lies even) come as fresh as the latest and most modern thought. To these younger people the old truths are necessary and vital things.

It is in this tutorial role, presenting old facts over and over again for the benefit of newcomers, that technical societies and journals have found public appreciation and their own salvation. They have attracted members and readers because only in their meeting rooms and pages can accounts of established technique be gathered from experts of the hour. We men of the Society of Motion Picture Engineers must face the fact that we are not repeating our knowledge for the benefit of newcomers. We have no established system of teaching.

During the first four years of our life we dealt with such fundamental matters as description and specification of machinery. Committees were set up to determine film standards, dimensions of sprocket holes, projector parts. There was an electrical committee, a committee on optics and one on nomenclature. The Transactions contain reports from these Boards, as well as general articles on the heating, ventilation, and illumination of the theater; descriptions of well-known studios, and papers on such subjects as reflection characteristics of screens.

During the next four years the activities became more technical and less fundamental, but the journal was becoming the recognized medium for the description of new inventions. We hear of filament projection lamps, the high speed camera, aspherical condensers, phonofilms, and television, as well as sub-standard film. There are résumés as before of laboratory technique and camera construction, and a concise history of color photography. But two new phases have begun to appear. Firstly, there is the description of specialized technical apparatus such as an edge waxing machine and the densitometer for use in printing; and secondly, there are discussions right away from the beaten track: "Can the movies teach?" "Pedagogical motion pictures," "Motion picture activities of the Canadian Government." The last three items can not be described as motion picture engineering.

Now we come down to the last two years. Highly specialized papers of local importance are in evidence: discussions on film splicing and the effect of scratches; communications on static and stress markings; the washing of film. Certainly there is a plea for fundamental camera standardization but this type of activity is less in evidence. On the other hand, we have in plenty articles and lectures only on the border line of motion picture engineering. "The importance of the village theater," "An exhibitor's problem," "The educational value of the movies," "The Public Theater Training School," and so on. But collaterally still another phase is appearing. We have a series of carefully written articles on laboratory technique all by a particular coterie of workers: "Photographic developers," "The handling of motion picture films," "Rack marks and airbell markings," "The use of desensitizers." These papers differ from the others in that while undoubtedly they contain new material they represent a conscious effort to write up in practical form the knowledge possessed by a few, so that it may be useful to many. It is the beginning of an organized effort to teach.

Without such tutorial lectures what impression must we give to the new and perhaps inexpert member? The fundamental things have all been said. They form the center of an ever widening circle of knowledge, a center hidden from him by the hand of time. He sees only the slowly extending circumference, embellished with arguments on technical trivialities and flirtations with artistic and industrial policy. It is only the tutorial lecture which can raise the hand and fill in the center of the circle showing him present progress in true perspective with past accomplishment.

I therefore make this very definite suggestion that we institute a series of lectures which will instruct the novice and put the expert in one field in touch with his fellow in another. One or two such lectures illustrated with slides and blackboard, dealing comprehensively with its chosen subject should be given at each meeting. They should be lectures, not communications, and should only encumber the TRANSACTIONS at the special decision of the publication committee.

Now, as I have tried to show, owing to the dearth of new scientific material, the Society is becoming concerned with subjects less and less deserving the title of engineering, and a time will come when we must seriously question the relevancy of our programs. My personal opinion, for what it is worth, is that we should by all means widen our interests. If we are to progress we must be worrying over the most vital problems of our parent industry. Before mechanical standardization was accomplished the need for such standardization was undoubtedly our most vital concern. Now we must go further afield. There are those amongst us, myself included, to whom a slight excess of graininess, projection flicker, travel ghost, or falsity of tone, is a disaster affecting us to insanity; but to the great warm hearted public these things are trivialities compared with whether the music is good, whether it is dark enough to hold hands, whether the poor heroine will marry the rich stock broker, and whether or not 'drink' films shall be banished from the motion picture screens. Our critics may reply that however important these things are they are not our *business*. Again I join issue. What we need is perspective. Concentrating on the part we must be aware of the whole. Looking at the umbra we must be conscious of the penumbra, of the vague shadow of things related to us but not our immediate concern. Besides, I do not believe an isolated body of engineers can be of the greatest use even as engineers. They must appreciate and be appreciated by the directorate, the players, and those who legislate and frame policy. This can only come by personal contact. We can invite to each meeting one or two figure heads, but to secure intimate fusion with our fellow workers in the movie field we must offer them a platform by welcoming them as members.

With extended frontiers and a mission to teach should we be making a sufficiently wide appeal? I think not. We must do more for our members.

At the present time we divide them into "associates" and "active" participants. The distinction is largely a matter of etiquette, it being considered beneath the dignity of men of standing to be admitted at the lower fee and with lower responsibility. But do we do anything for our active men? Do we tell the world that we have admitted them because they are especially proficient at their job? We don't, and thereby we join the minority in technical and learned societies. I am more familiar with English institutions but they will serve as examples. The Institute of Chemistry grants its A. I. C. and F. I. C., The Royal Photographic Society, its A. R. P. S. and F. R. P. S. Then there is the F. C. S. of the Chemical Society and most prized of all the F. R. S. of the Royal.

I should like to have suggested that we Engineers follow some such parallel and award, by examination or consideration of published work or public service, diplomas to higher grades of membership. A review of your American Societies shows however that this simply is not done. The American Chemical Society and the National Geographic Society have opened their doors to all comers regardless of any qualification save the ability to subscribe. In this way they have reached positions of enormous usefulness; but they can confer no diplomas on their members. At the other extreme your National Academy of Sciences which has developed exclusiveness to the point of admitting only eighty men, and those of the very highest rank affords them no satisfaction in the way of adornment to their names.

I believe however that we can draw the best from the two extremes of policy. We can extend our welcome to men who are not primarily engineers and we can close our doors to men of obviously little merit. In this way we can increase our membership yet secure such quality that merely to be included in our ranks will be its own mark of proficiency.

We cannot grant diplomas or place letters after the names of our members, but there is nothing to prevent us making tentative overtures to publicity. Were it possible to centralize ourselves instead of meeting occasionally at hotels we should undoubtedly possess our headquarters or club house. There we should enjoy some prestige in ability to lunch and entertain our friends, and to write letters on the Society note paper. Must all these things be denied to us?

I suggest that we issue on request stationary stamped with the Society's legend for members to conduct their business as from our headquarters.

Let us pass on to a totally different subject. At our last meeting there was much private and a little public talk of our relation to research within the industry. At the present moment a great deal of general work conducted impersonally for the common good is being done by the laboratories of the great firms who act as sponsors of this Society. Signs are not wanting, however, that the number or size of research establishments will increase. Just so long as the producing organizations are concerned with intercorporate rivalries then fundamental research must remain in abeyance to the perfecting of individual technical novelty. A time must come when the American industry as a whole must take steps to maintain its world monopoly, and at that time there must be a great growth and unification of research. It seems to me that the establishment of new laboratories and the co-ordination of programs is so inevitable that we should examine our personal attitude. There are those who believe that a technical society through its officers should play an active part in the direction of research. Others think that the two should be separate. Now, personally, I think that although we should do our best to foster research work we should make no effort to affiliate its control. Research is a matter of personal genius and leadership and is as little likely to thrive under a Board of Governors as a child under twenty nurses. The Society's concern is with the publication of research rather than with the initiation. For it to turn promoter would be putting the cart before the horse. Its real and active participation would arise from the fact that many new research workers would become members and probably officers of our committees. We should have the benefit of their presence, the opportunity of guiding their efforts and of disseminating new problems and should collaterally receive first class material for our TRANSACTIONS.

This brings me to the very knotty point of publication. No matter how persevering and adept our papers committee, they will work against heavy odds so long as the manuscripts submitted are unsuitable and so long as publication remains virtually obligatory owing to scarcity of material. We know that not all those engaged in the industry have literary talent or practice in scientific writing, even though they may relate a very real story. To help and to bring knowledge of the Committee's dilemma to these people should be our immediate concern. In the past printed slips have been circulated giving instructions for the modeling of papers. I suggest this practice be revived.

Three important points need emphasis. There is no room for selling talks in our pages; the articles must be relevant and describe without platitudes the subject named in the title; and finally the historical preamble should be eliminated. Those who attended our last meeting at Washington will remember that many of the papers opened somewhat as follows:

"Mr. President and Gentlemen, since Leonardo de Baptista Porta first threw a picture of his maternal grandmother on the wall of a Camera Lucida, and since the first humble moving picture of the Zoetrope, the motion picture industry has grown from the provision of a few nickelodeons to the education and entertainment of seventy-nine countries throughout the world. I, therefore, make no apology, Mr. President and Gentlemen, for introducing my present subject "An Improved Varnish for Sprocket Wheels."

If I have exaggerated the nature of this irrelevancy I have also exaggerated its brevity. The average prelude is much longer, is boring, and it tacitly assumes that the audience is ignorant of the general subject. I have prepared two little "dummy" papers to illustrate the points at issue. The first paper is written in the wrong way and the second, I believe, in the right. The subject chosen for the example is a purely hypothetical one and concerns the supposed advantages of projecting titles simultaneously with the acting in a photoplay.

1. A PLEA FOR SIMULTANEOUS TITLES.

"Will anyone deny that the most precious heritage of our Western civilization is the literary treasure accumulated in bygone centuries? How great a tragedy that this wealth cannot be exhumed for the motion picture screen! I say it is a tragedy, Mr. President, that the great epics of literature cannot be combined with the epics of the screen without periodical interruptions for the insertion of titles; interruptions which destroy continuity and offer at most a few selected phrases.

"To what sublime heights could picture drama rise if the script of the great bards illuminated the picture? Would not both emotion and intellect be stimulated at the same time through the eye? Think of the ship wreck of "Casabianca" thrillingly accompanied by those immortal lines "The boy stood on the burning deck." Think of Shakespeare's colossal tragedies annotated with the text; of King Richard the Second sitting on the damp hard ground, with those sublime thoughts on worms and epitaphs issuing in a balloon from his mouth!

"I might multiply these examples to infinity; I will refrain and turn to the practical description of this stupendous advance.

"For the past twelve years my firm, of whom I am the sole representative has spent all its waking and much of its sleeping thoughts on the solution of this problem. Finally, after unparalleled tribulation we have evolved a special camera operating a new type of film which produces the superb results which I now have the honor to present to you on the screen."

Contrast this effusion with:

2. "There has long been controversy over the relative merits of titles projected simultaneously and those alternating with the picture, a controversy settled in favor of the latter.

"Recent technical advances, however, make it desirable to reopen the problem. We have found that if a region not more than one-eighth of the total projected picture area be reserved in either the sky or deep shadows, a legend may be overprinted which does indeed assist the film story without detracting from its construction or artistic merit.

"We secure this effect without alteration to the original standard negative, by preparing a skeleton film title negative which is passed with the other two films through a printer. We have had to incorporate a stouter gate and a brighter light source, but otherwise the procedure is as standard.

"I will now project the films, the merits or defects of which will be left entirely to your judgment."

These papers have been worded as they would be read, but they will serve. The first is poor because:

(a) It does not state the problem;
(b) It weighs unduly one side of the problem;
(c) It advertises the importance of the writer;
(d) It conceals and fails to describe the invention;
(e) It attempts to force the final issue;
(f) It is much too long.

The second paper is good because:

(a) It states the problem;
(b) It describes the invention;
(c) It leaves the verdict to the audience;
(d) It is no longer than necessary.

So much for the Society's TRANSACTIONS. I tremble a little lest you shall think the criticisms presumptuous rather than helpful. They will have served their purpose if they merely stimulate thought and discussion from which may arise, perhaps some suggestions of concrete advantage to our Society.

DISCUSSION.

MR. RICHARDSON: I believe the question as to just exactly how we are going to build up or how we are going to maintain the present status of the Society to continue, to make it interesting to the members and make the members useful to the Society has occurred to many of us. That was made rather clear by a remark of the Chairman of the Committee of Standards and Nomenclature when I suggested to him something we can, as a committee, interest ourselves in. He said, "We must find something to do or go out of business." Dr. Hickman proposes a limitation of the publication of papers. I doubt the wisdom of that. The paper I shall read you took time that I could ill spare for its preparation. I took that time not because I particularly cared to present it to this limited audience who would not be particularly individually interested in the matter, but because in our TRANSACTIONS I should be able to reach the men I want to reach, and perhaps reach them in a somewhat effective manner. If I thought that paper was not going to be published I should not have prepared it. Possibly you would not lose much by the loss of my papers, and others might feel the same. Many would not undertake the preparation of a paper if they thought it was not going to be published. Dr. Hickman says new members want to know the things we have already gone over. In connection with my efforts in the publication of a certain department in a trade paper, I try not to lose sight of the fact that new men are continually coming into the business. However, don't forget this, that most of our new members do not attend the meetings, right away at least, and the only way we can reach these men is through the TRANSACTIONS.

Dr. Hickman spoke of the failure of many men to put a paper in good form. He did not tell us, however, that the germinal idea upon which the paper was founded was not of value. It probably was, though stated in poor form. The average man is not a writer. He does not know how to put his thoughts on paper. I do believe that the attitude which has been assumed by the Papers Committee of revamping papers is very necessary and very useful. I believe they have made some changes in one or two of my papers, and I never protested. If that is true then how can the one who has small experience in writing expect to get his paper published as submitted?

Dr. Hickman: I think Mr. Richardson has misconstrued my proposals. Any paper which contains even the germ of a useful idea is at present and will continue to be put through a process of amplification in the loud speaker of the Society's journal. What I would cut out ruthlessly would be irrelevancy both of the written and the spoken word. If a man says he is going to describe a new device, he should do so without devious introduction and without withholding the essential point of the invention.

As far as style is concerned, we do not expect perfection. Even we who criticize generally have to write our papers two or three times to the distraction of the stenographer, before they are judged acceptable.

Mr. Crabtree: The Papers Committee has always had in mind the type of papers mentioned by Dr. Hickman, namely, tutorial papers. For instance, we tried to get a paper dealing with the handling of film in the exchange and also one on the mercury vapor lamp. Several tutorial papers are on the present program. I think that if a tutorial lecture is good enough to interest the members then it is worth publishing, either completely or in abridged form.

With regard to types of papers, we have taken Past-President Jones' interpretation of the word 'engineer' and have tried to include on the program "any one in the industry concerned with the advancement of motion picture engineering and the allied arts and sciences." Whether this is desirable is a matter for discussion. Of course, the Papers Committee Chairman has absolute authority to reject or accept any paper. I take the attitude that it is desirable to retain a paper because it contains meat rather than reject it because the literary style is not first-class. In order to create a better impression among outsiders who judge the Society somewhat by the literary style of the papers, we do modify them. I don't see any objection to this because many men in the industry have valuable information available but have not been to college and taken a course in rhetoric or English composition. It is better for us to retain the idea than to reject it because the author cannot necessarily express it well in writing.

I have a suggestion to make with regard to membership. I learned that one gentleman the other day was informed that he was eligible for only associate membership because he was not an engineer but only a theater manager! He is one of the outstanding managers in the country, and I suggest therefore that the Board of Governors consider the matter of interpreting the word 'engineer' more broadly.

I don't think our TRANSACTIONS are getting a sufficiently large circulation. I put forth the suggestion that we advertise that the TRANSACTIONS are for sale. It is a matter for other persons to decide where advertisements should be inserted, but I think it ethical for the Society to advertise its TRANSACTIONS.

MR. L. A. JONES: It seems to me that the recasting or rewriting of a paper is a somewhat questionable procedure. In my opinion this should not be done without the consent and approval of the author. If a paper as submitted is not in suitable form or is not up to our usual standard the Papers Committee may be justified in rewriting the material after obtaining the consent of the author. In my own case I should resent having my paper rewritten and published without consultation. There is no doubt that the committee in many cases might effect an appreciable improvement but I think that they should be very careful and should obtain the approval of the author on the rewritten manuscript.

We have in the past rejected several manuscripts as totally unsuitable for publication. There is one reason which always warrants the rejection of a manuscript, that is an obvious advertising viewpoint. There is no doubt, of course, that we are justified in rejecting such papers without question, but I do believe that the Papers Committee before they publish a rewritten manuscript should obtain the specific approval of the author thereon.

MR. PORTER: I think Dr. Hickman has given us a most excellent analysis, and a number of the suggestions he makes are very good, but the problem which has been before us for a long time and is still before us is how can we carry out those suggestions? Let me go over a few in detail. For instance, tutorial lectures; that is fine, but what does the preparation of such a lecture involve? It involves the time of somebody who is sufficiently informed on the subject to do research, and to collect data, presented at different times and places to put it together for presentation as a lecture. A paid secretary could do that, but it gets back to the problem of sufficient finances to have such a secretary. I doubt if any of the members could take the time to prepare such lectures.

With regard to the question of rooms and a library, I don't think any of us will argue the desirability of permanent headquarters, but this costs money and how can we finance it?

I believe Dr. Hickman mentioned the possibility of giving some sort of degree to our members. There is merit in this and also matter for careful consideration. Membership in the Society is used sometimes for advertizing purposes and business reasons, and this we should have to control very closely. I don't know how we could do it without an examination. There are many things to be said on both sides for this suggestion.

With regard to widening our membership scope to include financial and artistic leaders, I think it is good, but we must give such people something for their money, and I do not see right away how we could interest some of the best known motion picture artists or screen actresses.

With regard to lending aid to research, I have thought of this for a long time. It seems to me there are two principal types of aid which we might be able to give: (1) by having the Society do research as a Society which takes a very large amount of finance. They are trying to do this in the Society of Automotive Engineers, one of the largest societies in the country, and they are not getting very far with it. We have, however, been doing something which I think very beneficial and of great aid in bringing together in our meetings men who are doing research; letting them talk over their problems and get acquainted. They find out that some of the things we are working on are not dark secrets. I think the Society has been lending tremendous aid by this means.

With regard to the prerogative of the Papers Committee in rejecting or correcting papers, both have been tried, and it seems to me we are working the thing out very well as it is. The Committee does not go out offhand and ask for a paper anywhere and take everything offered. They know the type of man proposing the paper, know the work he is doing, and whether the paper will be suitable before it is considered for presentation. So I think the whole matter boils down to a matter of finance. I was sorry that Dr. Hickman did not offer some practical solution to the problem of financing his suggested activities.

Dr. Hickman: Answering Mr. Porter's contention that I have criticized without suggesting adequate remedies, I wished to put these forward with those of other people during the discussion.

Is the tutorial lecture such a colossal task? If a man is to be drafted for some haphazard subject for this purpose, yes. But if experts in each field are asked to prepare comprehensive talks, I think not. Our own laboratory, which cannot be unique in this respect, possesses collections of slides permanently arranged in lecture form available to men who can talk about them without much effort.

The burden of my paper was that we needed more money and power which could only come from more members. I have not told you how this is to be done. I will tell you now. Your committee took a step in the right direction when it invited distinguished guests to our banquet. But what we really want is a militant attitude. With the whole of the industry located on the west of this continent we meet in the east. Instead of inviting a stray producer to our banquet we should go west and hold our meetings under the very noses of all of them. What is the objection? That it would be very expensive and half of us would not be able to attend. If the remedy is expensive and drastic it is no argument why it should not be applied. That is how we are going to get members into our Society, by selling them expert information at their doors, and not 3000 miles away.

Another thing which holds us back is our name Motion Picture *Engineers*. Cut out the word Engineers and shorten it to some more comprehensive title such as the Motion Picture Society; we should then not frighten away many of the people we wish to attract.

Answering the papers committee, have I a remedy for bad papers? Yes, it is the spreading of adequate information relative to the preparation of papers. This paper and this discussion has impressed the matter on those in the room and will continue to do so in the TRANSACTIONS in a way which has not yet been achieved. This was the motive that prompted my remarks.

MR. RICHARDSON: I don't think we should change our name and include the movie stars. To my mind one of the principal values of this society is the fact that twice each year I can come here, meet with other representative men and get acquainted with them, and they meet with me. I thus come to an understanding of what you are trying to do; you understand me better, and we each find through personal contact that the work of the other is of value to the industry and should be fostered and helped. I think we should make a determined effort to get all members out to the meetings. I don't think there is a man here who will not agree that every time we go away we say it was a good meeting; we have enjoyed the papers and benefited from the contacts with other men in the industry.

While I am sure Dr. Hickman's paper will accomplish good, I do repeat that one of the big values is the personal contact and the other the enabling of us to get our views and ideas on things before the men that Dr. Hickman says don't know we exist. They do know we exist, and they absorb our ideas and benefit from them.

Dr. Gage: There is one point which has not been emphasized so far in this discussion, but I think it is in the back of everybody's head. The purpose of a scientific society is to enable workers in a given field to think out loud. Everybody who is pushing the field of knowledge beyond the point which it has already reached has got to work by himself in his own cubbyhole. After a while he goes stale, and then if he can meet his fellow men and think out loud, it will be an inspiration to him. The entire motion picture industry needs the advance which the motion picture engineer can give. It does not mean that all of the people on the west coast must attend all the meetings. We should not get along as fast as at present, but all those people need the advance which only members of this Society can furnish. Somehow, those people must be given the idea that this Society is very important—in fact, essential—to maintain their livelihood. One of the things we are discussing is how to do this.

I should like to take a shot at the very interesting suggestion of tutorial papers. If we are going to have a tutorial paper to be presented and not printed, we must find some one who is willing to be the goat. As far as that goes, we have had at every meeting, and particularly at this meeting, a number of tutorial papers. We have had papers which will be printed in the Transactions, but also we have seen demonstrations which will not be printed in the Transactions because they are unprintable. You all understand what I mean by that. You cannot print demonstrations, and it is not practicable to distribute films of them. This is the start of what I wish to bring out in my idea of the difference between a tutorial paper and a research or engineering paper. The person who advances the art is sometimes able to make a wonderful exposition of what he has done. Sometimes he is a research worker who is not proficient in presenting his subject and is likely to give his ideas backwards. If his ideas are sufficiently good, we all want to hear him; we don't care how badly he presents them. It may be advantageous to rewrite his paper with or without his consent afterwards. That is the research type of paper, and as I say, the value of it is not altogether dependent upon the manner of presentation. On the other hand, the tutorial paper may have no new matter in it, but it may be matter which the new members who have not read the TRANSACTIONS will be glad to get. Such a paper must be well presented. It may consist largely of demonstrations, things not adequately reproduced in the TRANSACTIONS. It may take things already printed in the TRANSACTIONS and collect them together in one lecture. As to whether such a paper should be presented during a meeting of the Society of Motion Picture Engineers, where there is a limited attendance of people knowing more or less about the subject, or under the auspices of the Society —popular lectures to be given by people in various towns—is a subject worthy of consideration.

MR. ROOS: I am a member of the Society of Automotive Engineers. Recently we have been out for new members, more particularly with a view to doing better work. They are including service and repair men and even men having charge of large cliques of cars with a view to getting views of the other side. It seems to me it might be well to include in this Society the projectionists, those who have to do with machinery. You might go so far as including the electricians and directors. In Dr. Hickman's able paper he suggested the addition of artists; it might be well to have them as associate members. If they pay the dues, I think they are quite welcome.

DR. MEES: While I find Dr. Hickman's suggestions interesting and stimulating, I disagree with them almost from beginning to end. It appears to me that the idea that size has any relation to influence or efficiency is a complete error. Very few large bodies have done anything in the world. From the earliest days of history efficient organizations have been small, and the revolutions which have occurred in history have been made in almost all cases by a very few men who were working closely together. One of the most striking things in all history is the predominance of the little city of Athens in art and literature, and if you study those classical times, you will find that the men who made Athens great were very few and that they were mostly very well acquainted with each other. The same is true of the men who were responsible for the great developments of motion picture work. We are not responsible for the whole field of the motion picture but only for the technical development. It seems to me probable that a small group of men who know each other and are actively engaged in technical work are far more likely to be efficient in advancing the subject than a large society whose members have no really common interest. The important thing is to see that the Society does effectively cover the field and that all the people who are really qualified to be members are members, but the attaining of that result is one for which each member must be individually responsible. When he knows a man who should be in the Society and is not a member, he should undertake to bring him in.

I do not agree with Dr. Hickman that any change in the name of the Society is necessary. Our Society is the Society of Motion Picture Engineers, and we are, in our capacity as members of the Society, engineers dealing with motion picture work in just the same way as an automotive engineer is one dealing with the technology of the automobile or a mining engineer a man dealing with the technology of mining.

The defect of many of the papers read at the Society is that they have not been allowed sufficient time for preparation and correction and re-correction before they are presented. It takes a great deal of work to get a paper ready for a society, and only too often the papers are prepared under pressure and not sufficient time has been available to work on them.

Dr. Hickman: Mr. Richardson has objected to the changing of the Society's title because 'Engineer' does describe our business, and because its abandonment would involve a loss of technical prestige to certain members. I may remind him that there are some watering places in England situated up muddy creeks which incorporate the words "——-on-Sea" into their name to attract visitors who would otherwise be repelled by cold facts.

Dr. Mees has spoken of the value of a small society of the scientifically élite. I would remind him of the score or so of technical workers of the Royal Photographic Society who meet, unmolested by the nine hundred other members on whose subscriptions their journal subsists. He has spoken of Athens as the headquarters of ancient wisdom where small coteries of men did amazing things. I accept the simile but suggest that our "Athens" is in the west and that we have not yet gravitated thither. America is larger than Greece and geographical separation plays a large part. The valuable paper given us by Mr. Clarke only came to us because he happened to live in Rochester. Shall we not tap other sources of material when we move nearer to them?

STEREOSCOPIC CINEMATOGRAPHY.

E. J. Wall.

FOR the purpose of the following notes the definition of stereoscopy is the obtaining of two pictures from view points separated by the interpupillary distance and the presentment of the right-hand picture to the right eye and the left-hand picture to the left eye.

All other 'relief' systems are classified as pseudoscopic. You are all aware that it is possible to obtain a plastic effect by making a sharp image of a still object whilst others are moving. Thus if, when riding in a train or other rapidly-moving vehicle, one fixes the eyes on some object, such as a house that is not too distant, a sensation of relief is obtained through other objects moving relatively to the fixated object. This phenomenon has induced many misguided people to invent and patent similar systems for cinematography. Actually in no case is true stereoscopic effect secured. A somewhat similar result is attained by having one object or plane critically sharp, all others being more or less fuzzy.

Many inventors have recognized the fact that the individual pictures must be presented to their respective eyes, and have assumed that it is possible by taking advantage of persistence of vision to cause the brain to fuse into a unitary whole the successively, binocularly-presented right and left halves. Unfortunately the brain will not do this, but demands that the impressions be monocularly separated.

It may be thought at first sight that as there are two distinctly separate impressions conveyed to the brain cortices, that the latter should be able to fuse them correctly as long as they are presented within the time limit of persistence of vision, but it can not do this. A parallel case occurs when using different colors for each eye, a matter that will be referred to presently.

It should be added that actually these notes are, as it were, a byproduct of a search through the patent literature with another object altogether. No claim is made that they are complete or exhaustive. But having gotten them together it seemed worth while to arrange and publish them.

I have before now called attention to a ruling of the English patent office to the effect that any process that has been applied to the production of lantern slides or transparencies can not be patented for a motion picture, as the latter is but a series of transparencies. This ruling was laid down prior to 1911, in which year it estopped my application for a subtractive cine color process. I must add that since then the rule does not seem to have been very strictly used.

Agreeing as I do with this axiom and believing also that the motion picture, as we know it today, is but the obvious outcome of the earlier instruments the zoetrope or thaumotrope and kinetoscope, it would seem to me to be impossible to validly patent any principle that has been used for these old methods, though it is possible to validly patent modifications or individual means of securing the same effects. I have, therefore, included a few notes on early patents or methods.

Practically stereoscopic cinematography may be divided into two main classes: (1) the obtaining of the negatives, and (2) the projection of the positives.

The negative taking methods may be subdivided into four main classes: (a) the use of twin cameras; (b) the use of a single camera with twin lenses; (c) optical devices, such as prisms, mirrors, etc., before or behind the objective; (d) pictures taken alternately or with the medial lines not on the same planes. Obviously it is impossible to draw the lines of demarcation very strictly, as in some cases two or more methods are included in the patents.

Some of the early patents and literature references to stereoscopy are as follows:

As you are aware, P. M. Roget (Phil. Trans. 1825, *1*, 131; Pogg. Annal. 1825, *5*, 93) was the first to investigate the curious phenomena seen when a moving wheel is viewed through a slit or series of slits, though actually this was first noted, without any explanation by "J. M." (Quarterly J. Sci. Arts, 1821, *10*, 282). Roget's work gave rise to J. Plateau's wheel of life or zoetrope (Corr. math. phys. Brussels, 1928, *4*, 393; 1830, *6*, 121). This matter was examined by Faraday, Stampfer, Horner and others.

Stereoscopic zoetropes were described or patented by several workers:

Chas. Wheatstone (La Lumière, 1852, *2*, 88; Phot. News, 1873, *17*, 541).

J. Duboscq (Cosmos, 1852, *1*, 703; Bull. Soc. franç. Phot. 1857, *3*, 74. Cf. H. de la Blanchère, "Monographie du Stéréoscope", 1857, 49).

A. F. J. Claudet (E. P. 711, 1853; La Lumière, 1852, *2*, 88; Cosmos, 1853, *2*, 40; Bull. Soc. franç. Phot. 1865, *11*, 286, 292; Rev. Phot. 1858, 27; Kreutzer's Zeits. 1861, *4*, 203; Brit. J. Phot. 1865, *12*, 475; Phot. Notes, 1865, *10*, 274;

Brit. Assoc. Repts. 1865, *ii*, 9) patented a series of views seen through stereoscopic eyepieces, which were alternately eclipsed by a reciprocating slide. This then being the first use of an occulting shutter. The same device was used by Laing (Mech. Mag. 1865, (2), *xiii*, 190).

J. Czermak, Sitzber. Wien. Akad., 1855 described a stereozoetrope, called the stereophorolyt, and stated that Purkinje had suggested this in 1841.

A. D. Jundzill (E. P. 1,245, 1856) patented what he called a 'Kinimoscope' which was a zoetrope combined with a stereoscope, the pictures being viewed in a mirror and periodically eclipsed by a slotted disc.

P. Benoist (E. P. 1,965, 1856) placed two stereo views, exhibiting different phases of motion at right angles to one another, a grooved glass making an equal angle between them. By slightly reciprocating this glass the two pictures were alternately viewed.

R. Fisher & C. Aspray (E. P. 2,258, 1859) used a stereo slide with two views of the same object in different positions. An illusion of movement being produced by alternately eclipsing each eyepiece.

F. H. Desvignes (E. P. 537, 1860; Phot. Notes, 1860, *6*, 17) suggested the use of transparencies in the zoetrope and turning it on its side. This was also proposed by Thos. Sutton (Phot. Notes, 1860, *5*, 318; 1861, *6*, 82; 1865, *10*, 272; Kreutzer's Zeits. 1861, *4*, 95).

W. T. Shaw (Phot. Notes, 1861, *6*, 33, 64, 82, 198; Phil. Mag. 1861, *22*, 537; Brit. J. Phot. 1861, *8*, 170; Kreutzer's Zeits. 1861, *4*, 96, 170, 201, 227 and Reynaud (E. P. 4,244, 1877) also used this idea. Coleman Sellers (U. S. P. 31,357, 1861; Brit. J. Phot. 1862, *9*, 366; 1865, *12*, 402, and Cook & Bonelli (Bull. Soc. franç Phot. 1867, *13*, 201; Phot. Notes, 1867, *12*, 253) followed suit.

A. Ray (E. P. 100, 1874) patented a stereo slide with two views taken at opposite phases of motion and with rapid and alternate eclipse, either by a pendulum or oscillating beam, the phase persisting in the one eye while the other phase is presented to the other eye. He also suggested printing one picture in red and the other in green and viewing through rapidly reciprocated screens of the same colors.

Full use has been made in the compilation of these notes of Hopwood's "Living Pictures" 1st ed. 1899 and some articles by F. P. Liesegang, (Filmtechnik, 1920, *2*, 79, 139, 175, 213.)

Stereoscopic mutoscopes or kinetoscopes were patented by:

G. Demeny (E. P. 12,794, 1893; C. Dupuis (F. P. 376,714; addit. 7,621, 1907; Prestwich (E. P. 28,324, 1901): Tustmaier (D. R. G. M. 753,769); Claude & Gerstner (D. R. P. 239,380, 1910) and C. Bouin (U. S. P. 1,498,434; 1,498,435, 1924) and others probably.

Briefly dealing with the negative-taking principles it should be noted that J. B. Dancer in 1853 (Phot. Notes, 1856, *1*, 36) was the first to use a single camera with twin lenses and parallel axes. This also being used by G. R. Berry (Brit. J. Phot., 1855, *2*, 100) and l'Abbé Desprats (La Lumière, 1855, *5*, 52).

Side by side cameras were used by Fox Talbot and H. Collen (Phot. J., 1853/54, *1*, 200) by Claudet (Brit. Assoc. Repts., 1855, *xxii*, 6) and Moigno (Cosmos, 1852, *1*, 97) although in these cases the optic axes were convergent. It should be noted that true reproduction of an object is impossible when the lens-axes converge. For normal work this is incorrect, though the principle may be adopted with excellent results in special cases, when it is desirable to emphasize or exaggerate the relief, as in taking very small objects or those at a very great distance. If used for comparatively near subjects distortion of perspective must ensue, as can be readily seen if a building is taken thus, at an angle. The perspective lines converge one on the right and the other on the left. Actual fusion of the pictures is then impossible, except in one plane.

Naturally there was in the above cases no idea of cinematography but the principles are thus established.

When the pictures are taken one above the other, either immediately or at spaced intervals, strictly speaking there can be no true stereoscopic effect. Apparently Mazo et al. (F. P., 431,967, 1910) first suggested the use of a horizontally-moving film. But as it was well known that stereo pictures must be taken side by side in order to give true results, and for ordinary plate work the longer axis of the same was always placed horizontally, there would not seem to be much invention in this.

With reference to the method of using complementary color screens, though this ought possibly to be dealt with under the projection systems, it may be considered also as a negative system having been patented for this work. It, like the use of polarized light, is applicable to both negative-making and projection.

W. Rollmann, in 1853 (Pogg. Ann., 1853, *90*, 186) first suggested the use of complementary colors. He drew diagrams in blue and yellow and observed them through red and blue glasses. Actually this method is based on much earlier observations of the effects of using different colored glasses before each eye. The phenomena that occur here are rather striking and always indefinite. Sometimes one sees the right-eye color, sometimes that of the left-eye and again the compound color formed by the admixture of the two. The effects may vary within a few seconds, so that it is impossible to say what the results may be. These experiments date back to 1717.

On the other hand when viewing stereo pictures, so far as I am personally concerned, by this method, when the pictures have been once fused there is no trouble from the fluttering colors. What the cause of the indefinite coloring is not clear. There is, however, one fact that may play some part and which does not seem to be generally known, that is that the visual nerves from the right side of each retina proceed to the right-hand brain cortex, while those from the left side of each retina end in the left-hand cortex. Thus we actually see objects viewed by the right eye, partly by the left brain center and vice versa. And if you will recall for a moment the action of the lens of the eye, which is precisely the same as your camera objective, you will see that the right-hand side of all objects is seen by the left brain cortex and not by the right.

J. C. d'Almeida (Compt. rend., 1858, *47*, 61) was the next to suggest this method and his differed from Rollmann's in that in the latter system a body was seen with black edges on the background of the indefinite color, whilst d'Almeida used half pictures in colors, the high lights being formed of the colors used and the shadows being without color. His pictures were projected alternately with a single lantern on to the same place on the screen, the effect being actually based on the persistence of vision.

A modification of this system was suggested by Ducos du Hauron (F. P., 216,465; 1891: U. S. P., 544,666; 1895: Belg. P., 110,803). This was the superposition of the half pictures in blue and red and observation through the same glasses This method has become quite common, not only for cinematography but also for magazine illustration. These methods are very effective and the only disadvantage is that the audience must be provided with spectacles. This being also necessary when polarized light is used.

Another system was suggested first by A. Berthier (Cosmos 1896, *34*, 205; Compt. rend. 1904, *139*, 920; Zeits. f. Instrkde. 1912, *32*, 28) and later patented by Jacobson (U. S. P. 624,042; 624,043 1899) and F. E. Ives (U. S. P. 725,567; 739,182, 1903) and others, though not for cine work. In this a black and white line screen is placed in front of the sensitive surface, twin lenses being used and the positives viewed in the same way.

This method was modified by the Deutsche Raster-Gesellschaft and combined with the anaglyphic process. The negatives were taken through a two-color linear screen-film, the posterior surface of which was coated with panchromatic emulsion. Positives were printed by red and blue lights, the colors of the taking screen-lines, and observed through the respective spectacles.

A far better modification which I commend to those of you who may have a little time and more money to spare is the suggestion of Otto Wiener. He postulated the formation of a spectrum with an opaque barred screen, which should cut out certain regions of the spectrum, so that the transmitted rays would form white light. One screen was to be placed in front of the right-hand lens and another in front of the left-hand lens. But the latter was to cut out the transmitted bands and transmit the cut-out bands of the right-hand lens. All that one has to do then is to print positives and find filters, which while colorless shall respectively cut out and transmit the spectral bands used for taking. These used in front of the correct eye would give true stereo effect I am sorry that I can not say how such filters can be made. Miner's solution of the problem was to use polarized light and plane parallel quartz plates, which must be very accurately polished to the necessary thickness. It is here that you can spend the money.

One method of securing stereoscopic effects must not be omitted, namely that proposed by Lippmann, in 1891, and called by him integral photography, (Compt. rend, 1908, *146*, 446; Brit. J Phot., 1908, *55*, 192; Phot. Chron., 1908, *15*, 525; Phot. News, 1908, *52*, 359; Jahrbuch, 1909, *23*, 414; Phot. Coul, 1907, *2*, 121). He suggested that celluloid should be impressed on its anterior surface with minute hemispherical lenses, and the opposite side coated with an emulsion. A positive thus viewed would give stereo effect without the aid of any viewing instrument This method has been applied in France by Berthon & Keller-Dorian for color cinematography, but not so far as I am aware to stereoscopy.

We now come to that class which I have called pseudoscopic, embracing the greatest number of patents. Many of these may be looked upon as decidedly amusing, were it not for the fact that it is really pitiable to consider the enormous waste of time, energy and money that they represent.

Whether we actually want to see stereoscopically on the screen is an open question. Certainly it is doubtful whether this would add to the story, which ought to be the main feature from the point of view of the movie fan. So far as I can see, there is no method by which the effect can be secured without the use of individual viewing systems and these must naturally add to the cost of the show.

NEGATIVE MAKING METHODS: CLASS A, WITH TWIN CAMERAS:

HYMMEN, (E. P. 24,804, 1897) Merely claims making stereo views on cine film, which may also be used for book cinematographs.

WILSON (E. P. 3,477, 1898; cf. E. P. 197,409)
Two cameras geared together or double or triple camera may be used.

COLLET (F. P. 389,780, 1908).
Twin cameras simultaneously operated.

GARTMAN (F. P. 532,396, 1920).

Baudry, (F. P. 540,328, 1921).
Kohn (F. P. 562,217, 1922).
In these twin cameras with two films were used, with one picture space between each successive picture. These blank spaces being subsequently filled in with the alternate positives.
Maximoff (F. P. 548,981, 1922).
Negatives, on two films or wide film, simultaneously or successively taken, or by prisms or mirrors.
Kakabadze (F. P. 547,978, 1922).
Twin cameras.
Plantron, (F. P. 582,570, 1924).
Side by side cameras.

Class B, with Twin Lenses, with and without Convergent Axes:

In addition to the older patents already cited in connection with this system we have:
Holmes (U. S. P. 10,987, 1854).
Convergent lens axes for daguerreotypes.
The following are actually cine patents:
Sandow (E. P. 17,565, 1897).
Twin lenses for simultaneous exposure, preferably on single film.
Gergacsevics et al. (F. P. 385,635, 1907).
Simultaneous or alternate exposures, one being through the back of the film.
Villard (F. P. 386,946, 1908).
Warman (U. S. P. 1,146,293, 1915).
Adjustable convergence of axes by hand wheel on turntable.
Maslenikoff (F. P. 412,164, 1910).
Twin lens camera with two or double-width film. Or prisms may be used.
Mazo et al. (F. P. 431,967, 1910).
Negatives taken on horizontally moving film, with one or more picture spaces in between, which are subsequently exposed.
Theodoresco et al. (F. P. 449,996, 1912).
Horizontally moving film.
Coulon (F. P. 441,751, 1912).
Three images are obtained side by side on wide film, the outer ones being stereoscopic.
Cooper et al. (F. P. 477,440, 1915; U. S. P. 1,259,365, 1918).
Two films used. The lenses are adjustable as to separation.
Henley (E. P. 106,373, 1916; U. S. P. 1,284,673, 1918).
Twin lenses; may be used for color work.
Terashima, (E. P. 107,795; 107,796; 107,797, 1916).
Pictures taken on film moving horizontally. Lenses not on same level.
Polack (F. P. 528,184, 1917).
Losey, (U. S. P. 1,291,954, 1919).
Negatives vertically over one another on alternate spaces of horizontally moving film. Red and green filters are used. Claims results are seen in natural colors.
Prud'homme (U. S. P. 1,350,836, 1920; F. P. 545,323, 1921).
Pictures taken 'dissimultaneously'.
Hockly et al. (E. P. 177,916; 178,344, 1921).
Petra (D. G. M. 764,433).
Pictet et al. (F. P. 547,591, 1922).
Horizontally moving film with pictures not on same level.
Macy (U. S. P. 1,545,470; 1,545,589).
Twin lenses and film shifted between exposures.
Wilson (E. P. 197,409).
Hewson (F. P. 590,815).
Ranthe (D. R. P. 413, 231).
Cine stereo portraits for individuals.
Hoffman (E. P. 198,859).

Bouin (U. S. P. 1,590,804, 1926).

The following are included in this division. Their purport is the use of lenses of great diameter with eccentric diaphragms, thus practically forming two lenses.

Marechal (F. P. 557,563, 1922).

Pemberton (E. P. 175,466, 1920).

The idea of double diaphragms is old, see:

Norman (Phot. J. 1855, Sept. 15).

Lehrmann (D. R. P. 1858, Phot. Woch. 1878, *24*, 286).

Mitschell (Brit. J. Phot. 1881, *28*, 453).

Smith (Phot. J. 1911, *51*, 362).

Class C. Optical Devices.

Dickson (U. S. P. 731,405, 1903; E. P. 6,794, 1899).

Right-angled prisms at different distances in front of stereo lenses.

Szczepanik (E. P. 17,514, 1899).

Side right-angled prisms reflecting images to central prisms, thence to film.

Reynaud (F. P. 322,825, 1902).

Taking and projecting stereo pictures by means of a revolving shutter with 90 deg. reflecting sectors and 90 deg. cut outs. This revolved behind a fixed mirror, both at 45 deg. to optic axis.

Davidson (E. P. 13,468, 1902).

Three parallel mirrors at 45 deg. to optic axis in front of lens.

Sagl (E. P. 14,754, 1902).

Two semi-circular mirrors rotating on parallel axes so as to alternately reflect and transmit the images.

Davidson (E. P. 7,179, 1904).

Four mirrors parallel, or two pairs at right angles. May be used for color work

Chasles (F. P. 389,934, 1907).

Negatives taken on one film by Wenham prisms or mirrors. Twin projectors may be used or one machine, the positives being alternately colored red and green.

Stevens (U. S. P. 862,354, 1907).

Wenham or other prisms placed in front of lens.

Salow (U. S. P. 840,378, 1907).

Wenham or rhomboidal prisms in front of lens.

Parkas (F. P. 389,454, 1908).

Negatives on one or two films, with right-angled prisms in front of lens. Positives projected alternately by two lanterns on to screen with saw-tooth corrugated surface.

Vincent (U. S. P. 878,838, 1908).

Camera with two reflectors for each picture, to obviate transposing of pictures.

Kellner (U. S. P. 933,844, 1909).

Two mirrors parallel to one another and 45 deg. to lens axis to obviate transposition of pictures.

Maslenikoff (F. P. 412,164, 1910).

Twin lens camera with two or double-width films. Or Wenham prisms may be used behind twin lenses or in front of single lens. May be used for color. (addit. 12,150).

An occulting shutter for observer's use.

Richard et al. (F. P. 414,159, 1909; U. S. P. 1,209,498).

Straight parallelopipedon prisms with parallelogram base. The film moves horizontally and pictures laterally displaced. May be used for projection.

Nachet (F. P. 432,823, 1911).

Same as Chasles. See above.

Guillamin (F. P. 449,166, 1912).

Twin camera with film moving between the lenses, the images formed thereon by double reflection from two mirrors at 45 deg. to optic axis.

SALIMEI (F. P. 453,771, 1913).
Three lenses and right-angled prisms. May be used for color.

WAYDITCH (U. S. P. 1,071,837, 1913).
Two mirrors at right angles to one another and 45 deg. to optic axis and between them a pair of mirrors back to back which can be moved by Maltese cross so as to alternately reflect the images into lens. Prisms may be used.

SEGRE (F. P. 465,248, 1913).
Two or three spaced lenses with reflecting mirrors behind.

SAHULKA (F. P. 472,816, 1914).
Negatives obtained with the Helmholtz tele-stereoscope, and viewing by occulting shutter.

CERVENKA (U. S. P. 1,163,892, 1915; F. P. 488,332; 433,262)
Mirror at 45 deg. to axis and another mirror parallel to same which can be moved away for successive exposures.

COOPER ET AL. (D. R. P. 376,247; E. P. 2,490, 1914).
Rear lens component fixed while the front ones are adjustable laterally. Twin lens.

VINIK (U. S. P. 1,218,342, 1917).
Shutter with half silvered and half open sectors behind twin lenses. Apparently double width films used. Color filters may be used for taking and projection.

HAHN (F. P. 485,521, 1917; U. S. P. 1,282,073).
Two fixed mirrors at right angles to one another and 45 deg. to axis, with central mirror revolving on axis so as to be alternately parallel with each mirror.

RUFFIER (E. P. 152,367, 1917; F. P. 521,105).
Images from two lenses registered alternately on one film by two fixed reflectors between which is a revolving reflector which is alternately parallel with each of the fixed mirrors.

NORTON (U. S. P. 1,267,688, 1918).
Twin lens with narrow-angle prism behind, with bases directed to one another. Film supported in a carrier that turns it in to exactly right angles to the line of light from the prisms.
(U. S. P. 1,267,689, 1918).
Twin lens with pair of parallel mirrors at 45 deg to axis and rotating annular sector shutter.

TARANTA (F. P. 496,942,1918). Same device as Ruffier above.

PRUCHA ET AL. (U. S. P. 1,259,775, 1918).
Twin lens with oscillating rhomboidal prisms behind. Pictures taken alternately under each other.

BARUCH (U. S. P. 1,307,074, 1919).
Two right-angled prisms on bar in front of lens, reflecting images to two right-angled prisms reciprocally moved in front of lens, thus recording two pictures on one film successively. May be projected as usual.

ZIMMER (U. S. P. 1,334,480, 1920; cf. 1,556,216).
Mirrors at 25 deg. to optic axes reflecting the images to two mirrors at 155 deg. to one another, placed between the lenses, and the image being reflected back to a plane in the camera front.

HALLETT (U. S. P. 1,363,249, 1920).
Twin lens with convergent axes with mirrors behind, that reflect the pictures on to film between the lenses simultaneously.

BRIZON (F. P. 520,908, 1920).
Stereo effects obtained without lack of registration due to spaced lenses, exposures are made on two films through lenses of different foci to which rays from the same path are alternately directed by a rotating reflecting system.
(F. P. 522,999, 1919).
Revolving prism in front of lens, the view point being thus shifted slightly in a circular manner between exposures.

MAGRON (F. P. 525,495, 1920).
Simultaneous images through spaced lenses and reflecting prisms on adjacent picture areas. Double pull-down. May be projected in various ways.

GAULTERIOTTE (E. P. 174,674, 1920).
Twin lens with reflectors behind. Positives projected in mean coincidence with a shutter making 3000 to 5000 alternations per minute.

JEQUIER (F. P. 533,899, 1921).
Twin lens with reflectors behind. Images one above the other. Positives projected alternately through red and green screens and viewed with complementary spectacles.

SCHMITT ET AL. (F. P. 547,225, 1921).
Separated lenses and images formed alternately by series of right-angled prisms.

CHAVAROUX ET AL. (F. P. 550,383, 1921).
Mirror box with two mirrors at 45 deg. reflecting mages to parallel mirrors thence to two at right angles and thence to rotating mirror.

PICTET ET AL. (F. P. 547,588, 1922).
Two spaced lenses with reflecting mirrors that reduce the separation distance, so that the pairs are taken side by side.

JONES (U. S. P. 1,416,645, 1922).
Platinized mirror at 45 deg. behind lens, forming one image direct and another reflected.

NEWBOLD (E. P. 194,405; F. P. 559,593, 1922).
Revolving prism just in front of film, intermittently turned. May be used for projection

DOUGLASS (U. S. P. 1,429,495, 1922).
Pictures obtained on alternate areas through one lens and prism block. A shutter in front of prism passes the light first to the reflecting surface of one prism and then to the other. May be used for color.

CLEMENT (U. S. P. 1,477,541, 1923).
Twin lens with narrow angle prisms behind. Pictures projected side by side on single-width film. Projection by prisms reversely arranged and rotating shutter, in rapid succession.

THURA (F. P. 565,407, 1923).
Lens mounted at the front end of tube with prisms behind, refracting image to film; the tube being rotated between exposures, the latter made at each quadrant of circle.

AMES ET AL. (U. S. P. 1,479,211, 1924).
Mirror at 45 deg. to optic axis reflects image to a Swan cube in front of camera lens so that both images may be superposed.
(U. S. P. 1,479,212, 1924).
Adjustable side mirror with Swan cube for superposing images.

CUENIN (F. P. 568,497, 1923).
Two mirrors at right angles to one another and 45 deg. to axis, with oscillating mirror between reflecting images to one lens. Or the mirror may be replaced by two right-angled mirrors and two lenses between the 45 deg. mirrors.

FOURNIER (F. P. 598,030, 1925).
Two 45 deg. parallel mirrors behind two lenses. Also for projection.

MULLER (U. S. P. 1,494,795).
Negatives obtained as usual and printed alternately or successively and longitudinally of film.

LANE ET AL. (U. S. P. 1,536,718, 1925).
Angularly disposed mirrors in front of lens.

GIRSDANSKY (U. S. P. 1,580,242, 1925; E. P. 224,954).
Cone-shaped refracting body behind lens intermittently rotated.

SMITH (U. S. P. 1,585,129, 1926).
Spaced lenses and continuously rotary mirror between right-angled prisms

CORTINI (E. P. 220,965,1925).
Reflecting prism and two fixed ones on lens.

QUIDOR & HERUBEL (E. P. 247,404,1926).
Rotatable mirror or prisms in front of twin lenses

ROSENTHAL (D. R. P. 367,468).
Intermittently operated mirror.

GRIFFITH (U. S. P. 1,589,754, 1926; cf. U. S. P. 1,334,532, 1920).
Revolvable prisms behind twin lenses. May be used for projection.

CLASS D. PSEUDOSCOPIC AND MISCELLANEOUS:

RALEIGH (E. P. 13,644, 1898).
Negatives taken in usual way and printed in duplicate side by side or staggered and projected through a stereoscope.

THOMSON (U. S. P. 713,177, 1902).
A tripod top with parallel ruler attachment for stereo work. Merely the old Latimer Clark device, (Phot. J. 1853 / 54, *1*, 57).

BROWN (E. P. 12,997, 1903).
Cine camera oscillated during the taking of pictures.
(E. P. 13,410, 1903).
Series of pictures of previous patent.

MOON (E. P. 4,423, 1905).
Reciprocating camera and projector to and fro.

PECH (F. P. 363,920, 1906).
Twin-lens camera with two films alternately exposed, the negatives being displaced so that the dividing line of one is situated midway of the other picture.

JONCKHEERE ET AL. (F. P. 394,121, 1907).
Negatives taken with shifting film and printed in succession on single film.

MUNDVILLIER (F. P. 388,157, 1908).
Stereo camera with alternate exposures on two films with medial line displaced. Positives projected by axially-inclined machines with twin shutters moving in contrary directions, so that part of one picture is shown simultaneously with part of the other.

ARAGAO (F. P. 401,180, 1908).
Negatives taken on two films alternately with blank space between pictures; the two films being superposed so as to obtain a single positive with successive pictures.

TOUPILLIER (F. P. 405,422, 1908).
Twin lens camera with reflecting prisms at rear of lenses which throw the images in superposition on to mirror between lenses, where it can be viewed. May be used for projection.

WARSCHAVSKY (F. P. 400,512, 1909).
Twin-lens camera with single film oscillated behind lenses. Or an oscillating mirror with fixed film. Positives may be projected in like manner.

SEMAT (F. P. 419,762, 1910).
Twin lenses simultaneously or alternately used.

CALICHIOPULO (F. P. 426,960, 1911).
Shifting camera during exposure on an arc with its center in the center of the object.

SEMAT (F. P. 434,513, 1911).
To and fro movement of camera and projector.

SEGRE (F. P. 439,449, 1911).
Negatives taken from different positions in the order 1, 5, 3, 2, 4 or 1, 3, 5, 2, 4. Positives projected in like manner.

SCIAMENGO (U. S. P. 1,102,172, 1914)
Camera fixed, but tripod fitted with balls on which it can be shifted.

BORRALLEROS (E. P. 24,455, 1914).
Negatives with blank spaces between pairs, these being filled up in printing positives.

TERASHIMA (E. P. 107,797, 1916).
Extremely small pictures taken horizontally of film and displaced as to pairs, one being on an upper row and the other on a lower one.

Shorrocks (E. P. 110,292; 116,659, 1917; U. S. P. 1,324,179, 1919).
Camera moved in a straight line and also with angular movement whereby it is continually focussed on a given object.

Ivanoff (E. P. 15,999, 1915).
Camera moved on curved path, concave to subject.

Duhem (U. S. P. 1,243,272, 1917).
Tripod head by which camera can be moved vertically and horizontally at an oblique angle. Actually a panoram device.

Merrill et al. (U. S. P. 1,265,352, 1918).
Single lens camera moved continuously in a circle while directed at an object, thus giving alternate vertical and horizontal perspectives from the four quadrants of the circle.

d'Halloy (F. P. 489,516, 1918).
Twin cameras coupled together with single shutter alternately eclipsing.

Quick (U. S. P. 1,311,008, 1919).
Camera lens each half of which is alternately uncovered. The shutter passes through 'the focal center' of the same. May be projected in ordinary way.

Douglass (U. S. P. 1,313,587, 1919).
Twin lenses with pictures taken alternately through red and green filters and spaced apart on two films one picture space, so that the positives may be printed in succession and shown through rotary color sector shutter.

Harrington (U. S. P. 1,321,629, 1919).
Camera reciprocated between exposures.

Boorman (E. P. 165,587, 1920).
Camera displaced alternately right and left with the lens converging constantly on principal object.

Duhem et al. (U. S. P. 1,351,508, 1920).
Camera or lens shifted about an orbital path, of from 30 to 50 inches per second, while the axis is continually directed to one fixed point.

d'Halloy (F. P. 514,076, 1920).
Negatives taken alternately with one picture space between, so that they may be printed to form a continuous series in the positive.

Ball (U. S. P. 1,351,502, 1920).
Camera slung on cable suspended between two trees and being dragged along by rope. The motion of camera moving the film by means of pulley and endless belt.

Artur (F. P. 527,256, 1920).
Twin lens camera with one image placed under the other by means of reflecting prisms. Projection in the ordinary way gives stereo effect.

Brayer (F. P. 537,508, 1920).
Lens oscillated along its axis, so that the planes of picture vary in sharpness. A plan suggested by Claudet, Proc. Roy. Soc. 1866 / 67, *15*, 424.

Wright et al. (E. P. 192,104, 1921; cf. E. P. 205,881; F. P. 559,160, 1922).
Negatives obtained by revolving the lens about its axis and simultaneously shifting exposure gate. The lens may be uncovered twice or more at each revolution.

Oprescu (F. P. 534,602, 1921).
Same as d'Halloy.

Caslant (F. P. 541,590, 1921).
Moving camera in a cone.

Colombier (F. P. 543,836, 1921).
Alternate registration on same film with twin lenses.

Brizon (F. P. 547,867, 1921).
Shifting camera between exposures. Or interposing concave lens between object and objective, thus altering the focal plane of near objects, while that for distant ones remains the same.

Tutard et al. (F. P. 559,887, 1922).
Two mages of the same subject taken at different angles registered on the same picture space.

GRANDJEAN (F. P. 545,910, 1922).
Closely superposed or separated lenses with double film movement Projection in usual manner.

MAXIMOFF (F. P. 548,981, 1922).
Alternate or simultaneous taking and projection by various old systems.

TURK (D. R. P. 334,383, 1922).
Lens moved in circle.

RIGNON (E. P. 244,976, 1922)
Camera reciprocated right to left, back to front and up and down.

HARRINGTON (U. S. P. 1,403,549, 1922; 1,494,306, 1924).
Camera rhythmically oscillated between two exposure stations.

AMBROSIO (F. P. 567,890; 567,891, 1923).
Camera moved alternately at right angles to or circularly to lens axis.

MACY (U. S. P. 1,545,589, 1925).
Twin lens with lateral shifting means and one film.

TULLY (U. S. P. 1,579,974, 1926).
Oscillating camera.

RUNCIE (U. S. P. 1,488,027, 1924).
Negative taking as Brayer, see above. In projecting the screen is oscillated or reciprocated along the axis of projecting lens.

Projection systems may also be divided into two main classes: (A) systems in which the individual pictures are limited to their respective eyes; (B) pseudoscopic systems.

Class (A) may be subdivided into four subclasses:

(1) Occulting shutters before observers' eyes;

(2) Optical systems in front of eyes;

(3) d'Almeida's system in which the constituent pictures are projected side by side by colored light and viewed through colored spectacles;

(4) Anaglyphic method, in which the pictures are printed or projected in superposition in colors and viewed through complementary colored spectacles;

(5) Parallax or interlaced half pictures.

Class (A), 1. Occulting shutters in front of observer's eyes:

It should be noted that the occulting shutter was used by Stroh in the early '90's but was originally suggested by Howard Grubb, (Proc. Roy. Soc. Dublin 1879, *21*, 1). It has not been thought necessary to abstract every patent, only those that may present some special feature.

BOUCHARD (F. P. 210,569, 1891).

DEMENY (E. P. 12,794, 1893).
Pictures viewed through an aperture in rapidly rotating disc; practically the old thaumotrope.

PORTER (E. P. 12,921, 1897).
May be used for three-color work.

JENKINS (U. S. P. 606,993, 1898).
Shutter electro-magnetically operated from lantern.

DOYEN (E. P. 5,646; U. S. P. 660,006, 1900).
Ditto.

SCHMIDT ET AL. (F. P. 331,406; addit. 2,108; 2,736, 1903).
Ditto.
GAUMONT ET AL. (F. P. 336,460, 1904).
Ditto.
PREPOGNOT (F. P. 344,289, 1904).
Slotted shutter.
TREDELL (U. S. P. 830,217, 1906).
Shutter in opera glass.
TOPP (E. P. 17,955, 1907).
COLLET (F. P. 389,780, 1908).
MASLENIKOFF (F. P. 412, 164; addit. 12, 150, 1910).
Perforated disc that can be revolved by any means.
BANKL (F. P. 446,187, 1912).
SULLIVAN (U. S. P. 1,189,308, 1916).
HENLEY (E. P. 106,373, 1916; U. S. P. 1,284,673, 1918).
Occulting shutter or viewing in mutoscope with alternating apertures or color filters.
WRIGHT (E. P. 175,930)
ESTANAVE (F. P. 485,701, 1917).
Pictures in black and white or colors.
WAYDITCH (U. S. P. 1,276,838, 1918).
Projector with split condensers, occulting shutter, alternately projecting vertically-superposed four pictures.
ARESTIZABEL (E. P. 159,991, 1919).
MOORE (U. S. P. 1,396,651, 1921).
GANTES (F. P. 507,633, 1919).
BESSIERE (F. P. 533,542; addit. 24,806, 1921).
KAKABADZE (F. P. 547,978; E. P. 193,872, 1922).
MAXIMOFF (F. P. 550,596, 1922).
SCHWARTZKOPF (D. G. M. 773, 320).
GRENIER (F. P. 559,378, 1922).
HAMMOND (U. S. P. 1, 435,520; E. P. 208,261; F. P. 557,057, 1922; cf. U. S. P. 1,504,726).
Each picture projected three times and viewed through shutter.
COLOMBIER (F. P. 558,981, 1922).
KOHN (F. P. 562,217, 1922).
MARSHALL (E. P. 206,056).
SOCIÉTÉ JEANNERET (F. P. 565,675, 1925).
STOBIE (E. P. 247,239; 247,240, 1925).
BRUN (F. P. 586,075).

CLASS A, (2) OPTICAL SYSTEMS IN FRONT OF OBSERVER'S EYES:

DE PASS (E. P. 2,118, 1895).
Prisms or parallel mirrors.
SANDOW (E. P. 17,565, 1897).
Ordinary stereoscope.
MONIOT ET AL. (U. S. P. 653,520, 1900).
Lenses of stereoscope alternately opened and closed by pneumatic pressure.
BRUNET (F. P. 370,197, 1906).
Pictures projected on to curved lenticular mirrors of positive meniscus shape, held in front of eyes.
(Addit. 6,736, 1906).
Spherical mirror with non-centric surface.
REYNAUD (F. P. 379,483, 1907).
Continuously moving film and stereo viewing.
DUEBREUIL (F. P. 398,939, 1908).
Superposed pictures by prisms in front or behind lens.
COSMO (F. P. 403,866, 1909).
SEMAT (F. P. 435,964, 1911).
THEODORESCO ET AL. (F. P. 449,996, 1912; addit. 16,887).

Coulon (F. P. 441,751, 1912).
Miet (F. P. 483,554, 1914).
 Viewing through a card with two apertures, each of which limits the view to one picture.
d'Halloy (F. P. 482,879, 1916).
 Stereo viewing with occulting shutter
Terashima (E. P. 107,795; U. S. P. 1,349,018, 1920).
Bingham (U. S. P. 1,371,218; 1,392,475; F. P. 551,141, 1922).
Buttrand (F. P. 527,770, 1921).
Bernard (F. P. 540,393, 1921).
Maximoff (F. P. 548,981, 1921).
Favre (F. P. 552,226, 1921).
Harkness (E. P. 210,658, 1923).
Raymond (F. P. 557,966, 1924).
Kohn (F. P. 562,217).
Jarnier (E. P. 237,349, 1925).
Cairns (E. P. 244,857, 1926).
Girsdansky (U. S. P. 1,440, 457).
Bouin (U. S. P. 1,498,435; 1,515,428; 1,515,429, 1926).
Clymer (U. S. P. 1,540,604, 1926).
Baumann (D. R. P. 281,636).
Cooper et al. (D. R. P. 376,247).

The following patents refer to projection and viewing by polarized light:

Anderton (E. P. 11,520, 1891; U. S. P. 542,321, 1895; E. P. 1,835, 1898).
 The last patent is for a silver screen vertically striated and glass polarizers instead of Nicol prisms.
Wilson (E. P. 3,477, 1896).
Weinberg (E. P. 2,584, 1908).
Toulon (F. P. 519,824, 1919).
Bothe (D. R. P. 371,322, 1920).
Pictet et al. (F. P. 543,693; 574,226; E. P. 224,393; 231,563, 1921)
Franz (Austr. P. 3041, 1924).
Goerz (E. P. 231,848; F. P. 595,930).

Class (A) 3. d'Almeida's system in which side by side projection is used and viewing through colored spectacles Reference has already been made to the first suggestions for this.

Grottendieck (E. P. 24,821, 1894).
Gergacsevics et al. (F. P. 385,635, 1907).
Weinberg (F. P. 386,264, 1908).
Brown et al (F. P. 401,260, 1909; E. P. 146,547, 1918).
Mazo et al. (F. P. 431,967, 1910).
 (addit. 15,099, 1911).
 Use of split condensers for same.
Zavavicz (F. P. 413,366, 1910).
Rogers (F. P. 478,896; E. P. 14,583; 14,584, 1914; U. S. P. 1,294,172, 1919).
Gantes (F. P. 507,633, 1919).
Losey (U. S. P. 1,291,954, 1919).
Williams (E. P. 173,833, 1920).
Colombier (F. P. 558,981, 1922).
Allen et al. (U. S. P. 1,281,746).
Bouin (U. S. P. 1,581,834).
Griffith (U. S. P. 1,589,754).
Juillet et al. (F. P. 581,477, addit. 29,952, 1925).

Class (A) 4. Du Hauron's anaglyphic method, in which the colored pictures are superimposed and viewed by colored spectacles:

Du Hauron (U. S. P. 544,666, 1895).
Donisthorpe (E. P. 16,092, 1901; 1,483, 1903).
Grivolas (E. P. 10,695, 1901; F. P. 310,864).
Brown (E. P. 5,949, 1904; 146,547).
Gaumont (F. P. 420,163, 1909).
Double-coated stock with pictures on both sides in complementary colors. Non-actinic dye incorporated in emulsion to prevent penetration of light from one side to the other.
Munie et al. (E. P. 1 339, 1913).
Printing on bichromated film, dyeing, recoating and redyeing.
Henley (E. P. 106,373, 1916).
Lassally (D. R. P. 330,896, 1918).
Combination of anaglyphic and tetrachromic processes. Negatives taken in two coupled cameras through two color filters that divide the spectrum into four equal regions. One filter contains all the warm and the other all the cold colors. Projection by two machines through screens like the taking filters, the images being viewed through spectacles dividing the spectrum into two regions.
Grivolas (F. P. 310,864).
Hernandez-Mejia (U. S. P. 1, 282, 829, 1918).
Printing on double-coated stock not in register. Dyeing positives comp-plementary colors.
Parolini et al. (F. P. 519,746, 1919).
Berger (U. S. P. 1,422,527, 1922).
Tinting support so as to eliminate ghost of the color element.
Cf. Macy (U. S. P. 1,386,720; 1,498,743; 1,545,590).
Hammond (E. P. 210,411; U. S. P. 1,481,006, 1924).
Projecting shadowgraphs by anaglyphic method.
Lassally (D. R. P. 330,896).
Hildebrandt (D. R. P. 361,085).
Kohn (F. P. 562,217).
Lane et al. (U. S. P. 1,574,543).
Jequier (F. P. 533,899).
Carchereux (F. P. 574,566; 591,620; E P. 225,179).
Cheron (F. P. 581,143; addit. 28,918).
Juillet (F. P. 581,477).
Jarnier (F. P. 589,329; E. P. 242,627).
Hewson (F. P. 590,815).
Loiseau et al. (F. P. 590,910).

Class A (5) Parallax or Interlaced Half Pictures

Estanave (D. R. P. 206,474, 1906).
Bessière (F. P. 533.542; addit. 24,806; 562,381).
Kaynolt (E P. 117,342).
Boitesselin (F. P. 404,972, 1909).
Brizon (F. P. 527,507, 1920).
Balzar (F. P. 546,321, 1922).

Class B. Pseudoscopic and Miscellaneous

Bruce (E. P. 7,897, 1889).
Projection of stereo pictures on to revolving lath. Patented also by Lostalot (F. P. 511,536).
Coudray F. P. 256,159, 1896).
Projection with two lanterns.
Raleigh (E. P. 13,644, 1898)
Ordinary positives run through stereoscope.

BROWN (E. P. 10,277, 1903; 12,977; 13,410, 1903).
Oscillating camera and projector.
EVERSON (E. P. 3,998, 1905).
Twin lanterns, pictures superposed and total obscuration between pictures.
MOON (E. P. 4,423, 1905).
Same as Brown. See above.
WEINBERG (D. R. P. 212,883; 221,726, 1907).
MUNDVILLIER (D. R P. 217, 444, 1908).
COSME (F. P. 398,746, 1909)
Positives projected in superposition.
CERVANKA (F. P. 433,262, 1910; E. P. 22,910, 1911; U. S. P. 1,163,892).
Lateral movement of mirrors.
JUHASZ ET AL. (F. P. 433,905, 1911).
Projection on to transparent mirror at 45 deg. to axis of lens.
HIRSCH (D. R. P. 218,114, 1908).
CALICHIOPULO (D. R. P. 243,569, 1911).
HOBBS ET AL. (E. P. 20,507, 1912).
Mirror as screen.
DURAND (F. P 451,341, 1912).
Prisms in projector and pictures thrown on to different colored screens.
LUZY ET AL. (F. P. 461,600, 1912).
Projection of one picture by infra-red and the other by ultra-violet lights on to selenium cell.
JURSCHEWITZ ET AL. (F. P. 455,888, 1913).
Revolving lath as Bruce, see above.
GOLDSOLL (F. P. 458,849, 1913).
Projection on to 45 deg. transparent screen.
PAROLINI ET AL. (F. P. 483,875, 1915).
One picture projected on to wide-meshed screen and the other from behind to a solid screen.
SHORROCKS (E. P. 116,659, 1917).
Rotating camera.
FLINT (E. P. 116,549, 1917).
A cone-shaped box in front of screen.
HILDEBRANDT (D. R. P. 361,085, 1919).
Approximate superposition of pictures.
HEALE ET AL. (E. P. 117,053).
Silvered screen behind two fabric screens.
DICKINSON ET AL. (F. P. 510,735, 1920; E. P. 140,890; U. S. P. 1,383,538).
Splitting projected rays and throwing on to screen from two points.
D'HALLOY (F. P. 514,076).
FRIEDMAN (U. S. P. 1,358,685, 1920).
Pictures viewed by transparence or by projection on to glass with minutely-waved surface.
BRIZON (F. P. 528,819, 1920).
Projection of sharp and unsharp pictures.
HALLET (U. S. P. 1,363,249).
GUALTIEROTTI (E. P. 174,674).
Rapid projection 3000 to 5000 per second.
CORTINI (E. P. 220,965).
DAPONTE (E. 222,173, 1924).
Pictures projected through annular grey wedges, so that the illumination of one picture series increases as the other diminishes. There is thus a peculiar pulsating effect said to give stereo relief.
WRIGHT (E. P. 230,120; 239,270; 239,272).
Same as Daponte.
KAKABADZE (E. P. 223,476).
CLEMENT (E. P. 229,060).
JARNIER (E. P. 237,349).
RIGNON (E. P. 244,976).

MARSAT (E. P. 245,108).
Prismatic body, glass, liquid or thin glass plates before projecting screen.
MAGRON (F. P. 525,495).
BRIZON (F. P. 528,819).
MARION (F. P. 531,712, 1920).
Use of concave screen.
GARTMANN (F. P. 552,396, 1920).
Positives superposed in printing.
MOON (F. P. 536,287; E. P. 180,618).
Use of concave screen.
ANTIGNAZZA (F. P. 558,986, 1922).
Superposition of pictures from two machines after multiple reflections.
BAUDRY (F. P. 540,328, 1921).
Projection from single film or two with pictures successively superposed.
LEFEBURE (F. P. 540,399, 1921).
Two pictures printed in register, one being in warm and the other in cool tones.
PILNY (F. P. 542,282, 1921).
One image projected on to white screen, the other on to angled glass.
PAROLINI (F. P. 546,402, 1922).
Three or four screens one behind the other.
F. P. 569,056, 1923).
Use of metallic screen behind a gauze one.
BRIZON (F. P. 563,919, 1922).
Use of concave mirror.
DOUTRE (F. P. 567,378, 1923).
Seven screens one behind the other, increasing in opacity from the front to rear.
ALBINET (F. P. 570,540, 1923).
Stereo effects by projecting models of objects by aphengoscope together with cine films or stills from ordinary machine.
GIRSDANSKY (F. P. 570,609).
THURA (F. P. 565,407).
PENNING (F. P. 566,319).
POLACK (F. P. 582,114; 582,411).
JAMBOIS (F. P. 587,027).
Alternate projection.
MARECHAL (F. P. 588,247).
CARCHEREUX (F. P. 588,820).
Two or three pictures projected in colors or simultaneously.
SOCIÉTÉ STÉREO-CINÉMA (F. P. 591,335).
Alternate projection.
BOUDREAUX (F. P. 592,863; E. P. 232,255).
Ditto.
WIEGAND (D. R. P. 408,984).
Projecting faster than 35 pictures per second.
BUTTNER ET AL. (U. S. P. 1,144,108).
Diaphragms in front of projector lenses alternately moved.
LENHOFF-WYLD (U. S. P. 1,419,901, 1922).
Projection on to concave mirror by convex one.
SCHNEIDER (U. S. P. 1,448,153).
Picture viewed through transparent mirror which reflects light from an illuminated black surface.
MACBETH (U. S. P. 1,472,608, 1923).
Side by side pictures projected through twin shutters with radial slots in their peripheries.
OSBORN (U. S. P. 1,494,701).
Alternate projection.
BOUIN (U. S. P. 1,498,433; cf. 1,515,427).
Screen with frustrum-shaped areas on surface.

Bond (U. S. P. 1,519,392).
Smith (U. S. P. 1,585,129, 1926).
Two spaced lenses with another in between, the former being fitted with right-angled reflectors in front, to which rotary shutters reflect the images alternately with the central image. Pictures are projected in the order right, center, left, center, right, etc.
Leonard (U. S. P. 1,550,214, 1926).
Superposition of images and projected a plurality of times.
Cubitt (E. P. 236,639; 252,085, 1926).
Projection of sharp and unsharp images.
The latest device, which is stated to have been actually tested with satisfactory results, has been put forward by Roschdestwenski, a Russian engineer (Filmtechnik, 1926, *2*, 54) is to use two hollow semi-cylindrical bodies, or if you like to call them so, lenses, at right angles to one another and filled with air or some gas, before the usual screen. This can only be used for transmitted projection. It is said that it has been successfully tried with 6 x 8 meter, or 18 x 24 feet, screens.

DISCUSSION

Dr. Hickman: Professor Wall has shown us that the stereoscopic picture is not likely to be produced unless some means can be devised of getting the picture to both eyes at once I believe all successful attempts to solve the stereoscopic presentation of pictures have dealt with devices for getting things to stand out rather than with true binocular vision. I recall methods of keeping the camera quietly oscillating to cause the foreground to stand out from the background. Have these been found of any use?

I only wish to take issue with Prof. Wall on the subject of publication. If this monograph is as complete as the unique book on color photography which Prof. Wall prepared, I should think it would be worth its weight in gold to us.

Prof. Wall: Oscillation of the camera was suggested by Theodore Brown, who dealt also with the oscillation of the subject, and he went further by suggesting that the audience oscillate their heads.

REPORT OF PAPERS AND PUBLICATIONS COMMITTEE

THIS is the second term during which the Papers and Publications Committees have functioned as a unit. As is the case with all committees whose members are widely separated geographically, most of the actual committee work has to be done by the chairman. The serious difficulty in the way of continuing the combination of the two committees is the enormous amount of work involved. The combination experiment has demonstrated the urgent necessity of the establishment of a permanent secretary for the Society, to carry out the more arduous duties of the various committees.

Your Committee feels that it will be unable to spend the necessary time to carry out the work of the two committees during the next term. It is suggested, however, that the chairmen of the Publications and Papers Committees be selected from the same city, if possible, so that collaboration will be facilitated.

In dealing with the papers and their publication it has been difficult to decide where the responsibility of the Papers Committee ends and that of the Publications Committee begins. The attitude has been taken that the Papers Committee is responsible for subject matter and composition and is therefore responsible for modification of manuscripts. It is the duty of the Publications Committee to make up the manuscript for the printer, insert punctuations and carry the TRANSACTIONS through to publication.

A number of manuscripts as submitted for publication in Nos. 25 and 26 of the TRANSACTIONS were in a very unsatisfactory condition and it was necessary to entirely rewrite one paper and to considerably modify three others. Your chairman is indebted to Dr. Hickman for assistance in this connection and also to Miss Schmitt, our recording secretary, for punctuating and correcting manuscript. Although modification of an author's paper so as to improve the style and remove scientific inaccuracies, gives the reader a false impression as to the author's literary and scientific ability, your chairman has taken the attitude that such modification is very desirable in order to maintain the high standard of the TRANSACTIONS. Two alternatives are possible, however, namely, rejection of the paper or previewing and resubmission to the author before the meeting. When the Society becomes sufficiently large and influential so that authors will submit papers instead of being bullied into writing them, the Papers Committee will be better able to dictate terms to authors.

The growing influence of the Society has already been reflected in the greater ease in securing advance manuscripts for the Briarcliff meeting. The supply of papers, however, is not sufficiently great that it is possible to remove an author's name from the program because of neglect to submit manuscript in advance.

Owing to the difficulty of locating papers in the bound volumes of the TRANSACTIONS, it is suggested that the pages in the four yearly numbers of the TRANSACTIONS be numbered consecutively. This would greatly facilitate the location of back papers.

Your Committee has repeated the experiment of presenting a number of papers which are accompanied by motion picture demonstrations as part of the evening's entertainment and in view of the success of such sessions in the past their continuation seems desirable.

An attempt has been made to make each session a symposium on general subjects; such as problems of the theater, the laboratory, and the studio. The desirability of this procedure has been questioned but your Committee invites discussion of this matter at the special session which has been devoted to a discussion of the future policy of the Society.

In view of the importance of carefully grouping the papers with arrangements, your Committee considers it desirable for the Chairman of the Papers Committee to be ex officio a member of the Arrangements Committee.

Respectfully submitted,

J. I. Crabtree *Chairman*
C. E. Egeler
L. A. Jones
L. C. Porter
W. F. Little
J. C. Kroesen
J. A. Summers

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3	.25	16	2.00
4	.25	17	2.00
5	.25	18	2.00
7	.25	19	1.25
8	.25	20	1.25
9	.25	21	1.25
10	1.00	22	1.25
11	1.00	23	1.25
12	1.00	24	1.25
13	1.00	25	1.25
14	1.00	26	1.25

L. C. PORTER, Secretary, 5th and Sussex Sts., Harrison, N. J.

A sun for the stars

JUST as the stars shine at night because the sun lights them, so the motion picture stars twinkle and shine on the screen because sunlight makes them live for their audiences. For the arc that springs across a trim of National Projector Carbons is a tiny replica of the sun, brilliant, powerful, steady, possessing the proper color values for getting all that is in the film over to the screen and into the hearts of the audience.

NATIONAL CARBON CO., INC.
Cleveland, Ohio San Francisco, Cal.
Unit of Union Carbide and Carbon Corporation

National
Projector Carbons

QUALIFICATIONS FOR MEMBERSHIP

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.

ENTRANCE FEES AND DUES

The entrance and transfer fees, payable on admission to the Society, or upon transfer, are as follows:

Admission to grade of Active member	$30.00
Admission to grade of Associate member	$20.00
The transfer fee from Associate to Active grade is the difference between the admission fee, or	$10.00

The annual dues are as follows:

For Active members	$20.00
For Associate members	$10.00

REFERENCES

Applicants shall give references to the members of the Society as follows:

For grade of Active ...... Two (2) Active members.

For grade of Associate.... One (1) Active member.

References should be named who have personal knowledge of the Applicant's experience. It is suggested that Applicants give more than the required number of references.