MOTION-PICTURE WORK

A GENERAL TREATISE ON PICTURE TAKING, PICTURE MAKING, PHOTO-PLAYS, AND THEATER MANAGEMENT AND OPERATION

By

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INTRODUCTION

TWENTY years ago the motion picture was a child's toy. Today it is the basis of a business giving profitable employment to thousands of workers, offering amusement and education to millions of people, and involving an investment of capital that places it among the world's great industries.

¶ The motion-picture maker sets up his whirring camera in the wilds and the crowded city alike. He records the downfall of kings and the inauguration of presidents, the horrors of great disasters and the deeds of popular heroes; he spreads before us in moving panorama all that is interesting in nature and in man's work, in drama and in real life. Every large city has its motion-picture factory, and every village its motion-picture theater. Into communities too small to support a theater regularly comes the traveling exhibitor with his portable outfit, and shows in town hall, church, or country school house.

¶ For so important an industry a book of reference and instruction is more than merely justified; it is demanded. The motion-picture field is broadening day by day; the details of the business are becoming more multitudinous with each advance. The worker in one branch of activity must have some knowledge of all the branches to be able to get the best results in his own work. This treatise on Motion-Picture Work is the first compilation to cover adequately the entire field.

¶ The Art of the motion picture comprises two principal industries: the manufacturing and the exhibiting of film pictures. Both of these fields are covered in this volume. The worker in either field will be deeply interested in the detail and technique of the other, and will profit by that broader knowledge. The beginner requires a complete knowledge of both branches to fit himself for work in either branch.

¶ The drawings, diagrams, and photographs incorporated herein have been prepared especially for this work; and their instructive value is as great as that of the text itself. They have been used to illustrate and expand the text, and not as a medium around which to build the text. Both drawings and diagrams have been rendered as simply as was compatible with their correctness, with a view to making them as nearly as possible self-explanatory.

¶ This volume is a compilation of many of the most valuable Instruction Papers of the American School of Correspondence, and the method adopted in its preparation is that which this School has developed and employed so successfully for many years. This method is not an experiment, but has stood the severest of all tests —that of practical use—which has demonstrated it to be the best yet devised for the education of the busy man.

SCENE FROM "A PRIESTESS OF CARTHAGE," BY GAUMONT

THE OPTICAL LANTERN

INTRODUCTION

The optical lantern is a device for showing an enlarged reproduction of a small picture upon a screen before an audience. The small picture from which the projection is made is most conveniently a transparent picture, formed photographically upon glass by photographic processes. Modifications of the lantern may be made to show pictures upon opaque surfaces, such as newspaper clippings or souvenir postcards, or may show projections from solid objects. Still another modification of the optical lantern is that in which the motion head with its strip of pictures is substituted for the fixed slide in its carrier, and motion pictures are shown upon the screen.

The lantern consists primarily of a lamp for lighting the slide and a system of lenses for focusing the slide upon the distant picture screen. A slide holder is provided for receiving the slide and is adapted to hold it in position in the lens and lamp system. A lamp house is provided for the lamp, obscuring all light except that which passes from the lamp through the slide and through the lens system. The lens system usually is divided, one part being placed between the lamp and the slide, and the other part being placed between the slide and the picture screen upon which the image of the slide is to be projected. The lenses between the lamp and the slide are called the condensers, and the lenses between the slide and the picture screen are called the objective lenses, or more briefly, the lens.

THE ELEMENTS OF THE LANTERN

The parts going to make up the complete lantern system ready for projection may be listed as lamp, lamphouse, condenser, slide, slide holder, lens, and screen. The complete system of the lantern is shown in Fig. 1, which shows in diagram the elements arranged in their proper relation when in use. At *L* is shown an electric arc, in the lamphouse *LH*. In the front of the lamphouse is mounted the condenser *C*, consisting of two condenser lenses in a frame. In front of the condenser *C* is the slide holder *SH* and in it the slide *SL*. In front of the slide holder and its slide, and at a little distance, is the objective lens *O*, while at the extreme right is the picture screen *PS*, upon which the lens *O* concentrates in focus the light received from the lamp *L* through the condenser *C* and slide *SL*.

The Optical System. The light originates at *L*, and it is desired to get as much as possible of that light upon the screen *PS*. For that purpose, the system of lens glasses is used. Projection without lenses is possible, but not in any way practicable. To collect as much as possible of the light of the lamp *L*, a lens glass having a large surface is placed near the lamp. This is the back condenser lens, or left lens of the two in the condenser case at *C*. All the light

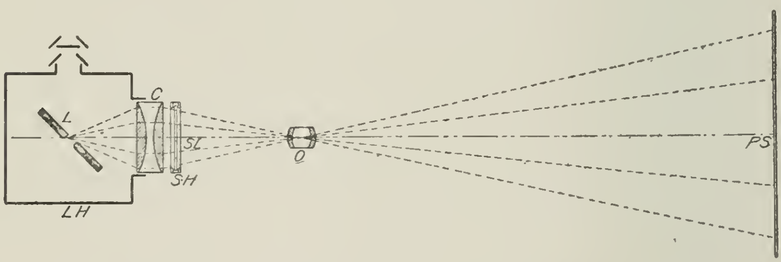


Fig. 1. Complete Optical System of the Lantern

falling upon the flat surface of the back condenser lens is bent into substantially straight lines, and thrown upon the curved surface of the front condenser lens. The front condenser bends the rays of light again and causes them to converge at the point of the focal center of the objective lens *O*, where they cross and proceed to the picture screen *PS*. The distribution of the light upon the picture screen by the condenser lenses and the objective lens, without a slide in the holder, is perfectly uniform when lamp and lenses are properly adjusted. When a picture slide *SL* is placed in the holder *SH*, some of the light is obstructed by the darker spots of the picture while nearly the full intensity of the light is permitted to pass through the transparent portions of the slide. The result is that the picture of the slide is transferred to the picture screen in the form of a shadow of the slide, and in much enlarged form. To secure a sharp image of the picture of the slide upon the screen *PS*, the slide *SL* must be exactly placed in the cone of light at the proper distance from the lens *O*. This distance is determined by the amount of curvature of the glasses of the lens, a dimension which is called the "focal length" of the lens. For a fixed slide of ordinary size, the lens is chosen of such focal length that the slide is properly placed nearly against the face of the condensers, as shown in the diagram. For microscopic projection a lens of very short focus is chosen and the slide is placed very near the lens, while for motion-picture projection a lens is chosen having about one-third the focal length of a lens for projecting fixed slides, and the motion-picture film is placed much nearer to the lens and much farther away from the condenser than is the slide *SL* in the diagram of Fig. 1. The length of the focus of the lens and the position of the slide being determined, the finer and final adjustment for causing the slide to be focused properly upon the picture screen is made by moving the lens itself slightly into an accurate position of focus.

The Inverted Slide. From Fig. 1 it can be seen that the ray of light which passes through the top of the slide *SL* ultimately reaches the bottom of the picture screen *PS*. Likewise, the ray of light passing through the bottom of the slide reaches the top of the picture screen, and all intermediate points are found upon the picture screen in their proper order and in inverted relation with reference to the position of the slide in the holder *SH*. In order to effect the projection of the picture upon the screen with the top of the picture at the top of the screen, the slide is inserted in the holder inverted.

Not only is the slide reversed top for bottom, but it is reversed also right for left. A square slide may be placed in the slide holder in eight different positions, only one of which is correct. The American standard slide, which is a little wider than it is high, still can be placed in the slide holder in four different positions, only one of which is correct. In strictly picture slides, it may be sufficient to get the bottom of the slide at the bottom of the screen, but where there are letters or words, such as signs, in the picture, or titles written or printed, it is necessary also to have the left side of the slide at the left side of the screen

Placing Slide in Holder. The simplest rule is the safest. *Take the slide in the left hand and look through it, holding it so that it is correct, top at top and left at left, holding it by the upper left-hand corner and viewing it as it is to be viewed upon the screen by the audience.* This position of the slide and of the left hand holding it is shown in Fig. 2. *Face the screen standing at the side of the lantern, and with the right hand take hold of the lower left-hand corner of the slide.* This position of the hands is shown in Fig. 3. *Now release the slide with the left hand and without changing the grip turn the hand with the slide, keeping the same side of the slide toward the eyes, so that the slide is held inverted* as shown in Fig. 4; *still facing the picture screen, drop the slide into the carrier and push the carrier into place in the slide holder.* In brief, *hold it so that it "reads right," catch it by the lower left-hand corner and drop it into the carrier.*

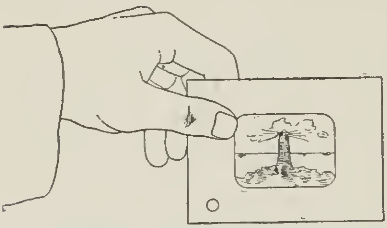
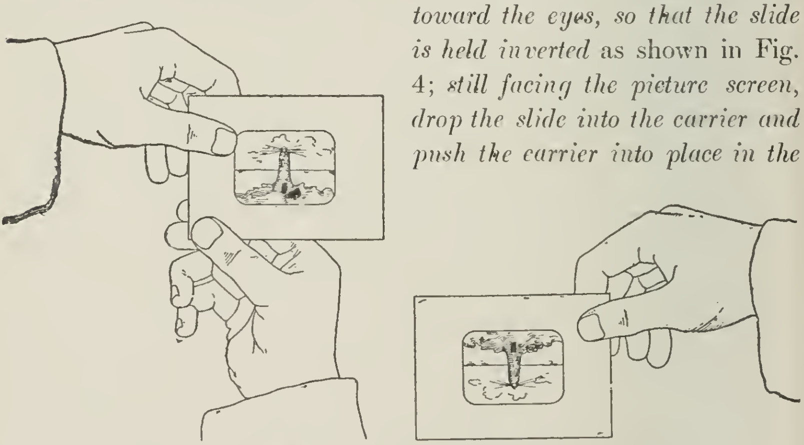


Fig. 2. Method of Holding and Turning the Slide for Proper Insertion Into the Lantern



Figs. 3 and 4. Method of Holding and Turning the Slide for Proper Insertion Into the Lantern

Thumb Spots. Finger marks on the face of the slide show plainly on the picture screen, and are very undesirable; the moral is to clean the slides before showing them the first time and then to keep them clean by handling them only by the edges or masked margins where finger marks if any will not show upon the picture screen. The "thumb spot," however, is a different matter. In Fig. 5, at the upper right-hand corner of the figure and, therefore, at the lower left-hand corner of the slide when viewed as in Fig. 2, is shown a small circle or spot. This is the thumb spot, and if the thumb of the right hand is placed upon this spot the slide will go into the carrier properly inverted and will appear in its proper position on the screen. Thumb spots may be bought, cut from gummed paper, as circles or stars, or may be clipped square from paper and gummed on. The advantage of the thumb spot gummed upon the outer surface of the glass is that it may be felt, and the lantern operator knows without looking at his slide that it is in the proper position and will appear correctly upon the screen. The disadvantage of the gummed thumb spot is that it sometimes comes off.

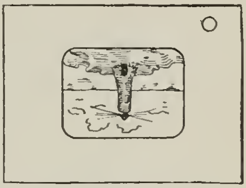


Fig. 5. Thumb Spot on the Lantern Slide

Another method of providing for the thumb spot is to paste it upon the mask, or upon the inside of the glass of the slide (some masks are printed with thumb spots upon them) but this has the disadvantage of requiring the operator to look at the slide to find the thumb spot, and does not warn him automatically by touch in case one slide in a set has been turned accidentally and the operator is mechanically feeding through the set after having tested the top slide of the pile. The inside thumb spot cannot be lost from the slide, and may be supplemented by an outside spot gummed on if the operator will take the trouble.

Where slides are in sets, as in slides for illustrating songs, the slides are numbered, the thumb spot sometimes being used for the number of the slide in the series.

THE LAMP

An oil lamp is sufficient for toys, an incandescent gas mantle or an incandescent electric-lamp bulb for a parlor exhibition. For larger rooms requiring a longer distance from the lantern to the picture screen, and requiring a larger picture upon the screen because of the greater number of people who are to view it and the consequent greater distance from the screen of the more remote spectators, a brighter illuminant is required. This is found in acetylene gas, in the lime light, or in the electric arc.

Acetylene. Acetylene is a gas produced for illuminating purposes by wetting calcium carbide with water. It produces a very brilliant white light, suitable for lantern projection, but not so brilliant as the calcium light or the electric arc. The acetylene light has the disadvantage of offering a comparatively large flame, whereas the calcium light (or lime light) and the electric arc both offer a light which comes from a very small surface, practically from a single point. The light from the point is better for projecting purposes.

Acetylene generators all provide a water tank and a carbide chamber. They vary in the method or means for admitting small quantities of water to the carbide chamber or small quantities of carbide to the water tank. In some generators, the water is carried to the carbide by soaking up a wick, the amount of gas generated being regulated by the speed with which the water can reach the carbide by soaking through the wick. The gas must be used as generated, and when not needed the generation is stopped by lifting the wick from the water. In others, the water drops upon the carbide through a needle valve which is capable of a regulation to give exactly the flow of gas required. In others, the carbide is placed in a floating chamber which is lifted from the water by the generation of gas, being lowered into contact with the water again when the gas is used. Any generator which accumulates gas under pressure is more dangerous than one in which no provision is made for storing the gas, and the gas must be generated exactly as required. Any gas generator suitable for supplying gas to automobile headlights is suitable for supplying gas to a projecting lantern, and the tanks of compressed gas much in favor for automobile lamps are suitable also for projecting lanterns. The only connection required between the gas supply and the burner is a single flexible rubber tube.

The gas burner, designed especially for projecting lanterns, has a row of jets in a straight line, placed endwise to the condenser. These are bunched as closely as possible, a group of four or six in a line having a length of an inch or an inch and a half. A reflector also may be used.

Lime Light. This is a form of incandescent gas burner. The "lime" is a cylinder of lime set upon a pin in such a manner that it may be turned and raised and lowered as well. A gas jet plays upon it and heats it to a white heat at the point where the flame of the jet touches the lime. The glowing lime gives a brilliant white light, all the light proceeding from a very small area of the lime cylinder. The projection from such a light is very good, but the light is troublesome and to a great degree unreliable. The lime burns into a pit at the point where the flame touches it, and must be turned at short intervals to bring a new spot under the flame. If not turned, the tongue of flame will be turned back by the curved walls of the pit and may even reach to the back condenser, striking it and cracking it. Sometimes also the lime without apparent reason splits and falls from its support. That means stopping the show until a new lime has been placed and the jet again properly adjusted.

The gas jet used for the lime light will use ordinary illuminating gas urged to a greater heat by a jet of oxygen; thus two rubber tubes are required leading to the lime-light burner. When the illuminating gas is not available, a supply of hydrogen and oxygen is required, or some of the many substitutes.

For many years, prior to the commercial exploitation of the electric-arc lamp for the projecting lantern, projection before audiences of any size or importance was made almost exclusively with the lime light, and much stage lighting for theaters was done with it. "In the lime light" is an expression not yet lost to the language, although electricity long since has routed the lime light from the theater. Instructions for the proper use and care of the lime light, including the making of the burners and of the gases to be used in the burners gas generators, gas washers, gas purifiers, gas saturators, and so on in innumerable variation, are found in abundance in books and magazines of a decade since, but the general subject has little interest to the modern optical-lantern operator or motion-picture projection operator.

The Electric Arc. The only modification of the ordinary electric arc required to adapt it for use in the optical lantern is to make it as much one-sided as possible, that is, to arrange it so that as much of the light as possible will be thrown toward the condensers.

The Direct=Current Arc. The positive pole is connected to the upper carbon of the lamp, the negative to the lower carbon. The carbons are placed end to end and in a straight line except that the axis of the lower one is slightly in front of the axis of the upper one, that is, toward the condensers. In the direct-current arc, a cavity or crater is formed in the positive carbon. The crater is the hottest and brightest point in the lamp, and from it proceeds the greatest amount of light. By displacing the negative or lower carbon slightly, say, an eighth of an inch, the positive or upper carbon is caused to burn with a diagonal end containing the brilliant crater, and the light of the arc, therefore, is thrown off to one side of the lamp, namely to that side toward the condensers. The proper relation of the carbons is shown in Fig. 6, and the direction of greatest intensity of light is shown by the dotted lines radiating from the upper carbon. To bring this maximum light upon the condenser surface, the line of the carbons must be inclined as shown, and at about the same angle, say, twenty to thirty degrees. If inclined too much, the end of the lower carbon will throw a shadow upon the condenser, and if not inclined enough the greatest brilliancy upon the condenser will not be obtained. In this connection it may be noted that the length of the arc governs to some extent the angle at which the lamp may be inclined, since with a longer arc a greater inclination may be had before the lower carbon shades the condenser from the crater. The carbons should be set parallel. If set at even a slight angle, the feed as the carbons burn away will change the displacement of the two ends and change the value of the light.

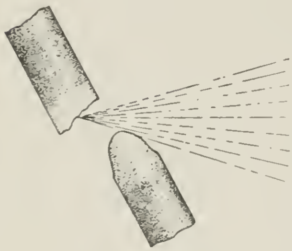


Fig. 6. Motion-Picture Arc for Direct Current

A second method of setting the carbon for the direct-current arc is shown in Fig. 7. The positive carbon is set horizontally and when properly adjusted for position, points directly toward the center of the condenser. When fed, it moves directly toward the condenser, and thus always keeps its crater "centered," whereas in the adjustment of Fig. 6, the burning away of the upper carbon constantly raises the crater from the center line of the condenser, and the feeding of the upper carbon constantly lowers the crater. Unless

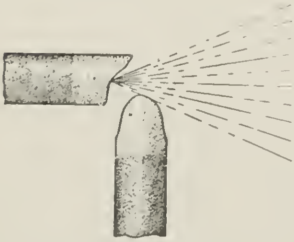


Fig. 7. Stereopticon Arc for Direct Current

the feed is exactly proportioned to the burning away, and exactly compensates for the burning away, the crater will get off the axis of the condenser and the lamp as a whole must be moved to bring it back. Unfortunately the adjustment of Fig. 7 does not give as brilliant an arc as the adjustment of Fig. 6 when a long arc is used, but when a short arc is used the carbons become so near in Fig. 6 that Fig. 7 becomes preferable and gives the better light.

Stereo vs. Motion Arc. Fig. 7 is called the *stereopticon arc*, and Fig. 6 is called the *motion-picture arc*. Stereopticon or fixed-slide projection, with the large slide nearly three inches square and enlarged to nine feet square on the screen, requires a magnification of thirty-six diameters. A fifteen-ampere arc is sufficient to give the illumination required; a forty-ampere arc gives so much heat that slides will be broken by the heat if left in the slide holder for many seconds. With a fifteen-ampere arc, the adjustment of Fig. 7 gives a better light than that of Fig. 6 because in Fig. 6 the carbons are brought so close to maintain the short arc that the lower carbon shades the condenser. Motion-picture projection, with the image only three-quarters of an inch by one inch, enlarged to seven and one-half by ten feet on the screen, requires a magnification of one hundred and twenty diameters—more than three times the lineal enlargement and more than ten times the surface enlargement of the stereopticon projection. A forty-ampere arc is desirable, and the longer arc adjustment between the carbons permits the adjustment of Fig. 6 to attain the greatest possible brilliancy upon the condensers. The heat is intense and would ignite the celluloid film almost instantly were the film to remain at rest in the heat, but the period of rest of the film is only one-fourteenth of a second for each picture, a period of time too short to permit it to begin to blaze.

The Alternating-Current Arc. In alternating current there is neither positive nor negative pole, and both carbons are alike in the lamp, each having a crater, but neither crater as hot for the same current value as the direct-current crater for the same current. When the carbons are set in line, the light of the alternating arc is distributed equally in all directions, but when they are set at a slight angle to each other the greater portion is thrown outward from the angle. The proper setting is shown in Fig. 8. The angle there shown is about as great as will be found possible to get the best light, but the angle between the carbons depends to some extent upon the amount of current used and the length of the resulting arc. A larger current is required with alternating than with direct current, from fifty to sixty amperes being common.

Cored Carbons. Carbons are made either with the same consistency of carbon through the pencil or with a hard shell and a soft core, the core being about the size of the lead in a lead pencil. When the cored carbon is used, the crater will form in the end of the core, keeping in the center of the carbon pencil, and the vapor of the soft core will hold the arc between alternations. With the alternating-current arc, the cored carbon is a necessity, producing the arc shown in the diagram of Fig. 8, whereas without the cored carbons the arc has a tendency to run to the nearer edges of the carbons, as shown in the diagram of Fig. 9, with consequent loss of brilliancy upon the condensers. The solid carbon is generally used in the direct-current arc. For one reason, it costs less money. The light will be found easier of control, requiring less skill on the part of the operator if the cored carbons are used on the direct-current arc also. Soft carbons give a better light than hard, but burn away faster and require more attention and adjustment.

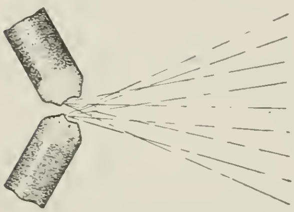


Fig. 8. Proper Arc for Alternating Current, with Cored Carbons

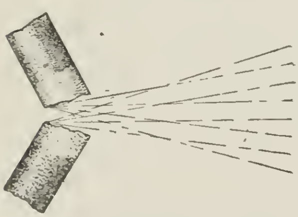


Fig. 9. Improper Arc for Alternating Current, with Solid Carbons

Lamp Adjustments. The lamp has four adjustments: (*1*) vertical, or up and down; (*2*) focusing, or back and front, toward and from the condensers; (*3*) lateral, or right and left; and (*4*) feed.

The vertical, focusing, and lateral adjustments for the position of the arc are mentioned in the order of their frequency of use. The feed is the adjustment of the carbons in the lamp, and should take place without changing the position of the arc; feed provides for the burning away of the carbons by the arc, the position of the arc being changed independent of feed by the three remaining adjustments. The different types of lamps made and sold by different manufacturers vary greatly in the details of the adjustments. In taking charge of a lamp, look for the four adjustments. The fourth or feeding adjustment will be found the most prominent, being the one most used. Invariably, it is controlled by a knob projecting from the back of the lamphouse. Turning the knob in one direction brings the carbons together and turning in the other direction separates them. To start or "strike" the arc, turn the knob to bring the carbons together, when a slight sputtering and a dim light will announce that the carbons are in contact; then reverse the knob quickly for a part of a turn to draw the carbons apart. The current will continue to flow through the separated carbons, and a brilliant arc will be formed. The proper adjustment is the brightest arc obtainable, all adjustments being considered. This is not the longest arc nor the shortest arc. With the long arc the current is reduced and the intensity of the light of the crater is less; while with the short arc the intensely brilliant crater is concealed between the two carbons. As the carbons burn away, the arc becomes longer and weaker and ultimately will "break" and die out, requiring that the arc be "struck" again by feeding the carbons down into contact and backing away as in striking the arc at first. The carbons must be fed down skillfully to compensate for the burning away before the arc breaks. The feed may be gauged through the peephole of the lamphouse, or by the illumination of the picture screen, or by the sound of burning in the lamp. At frequent intervals, feed down slowly; the illumination of the screen will become brighter to the maximum and then lose a little, indicating by the slight loss that the proper adjustment has been passed. Then back up slightly to the best adjustment and after a half minute or a minute feed down again in the same way. This method of feeding must be practiced so skillfully that the audience will not notice the slight changes in illumination by which the lantern operator is feeling the pulse of the arc.

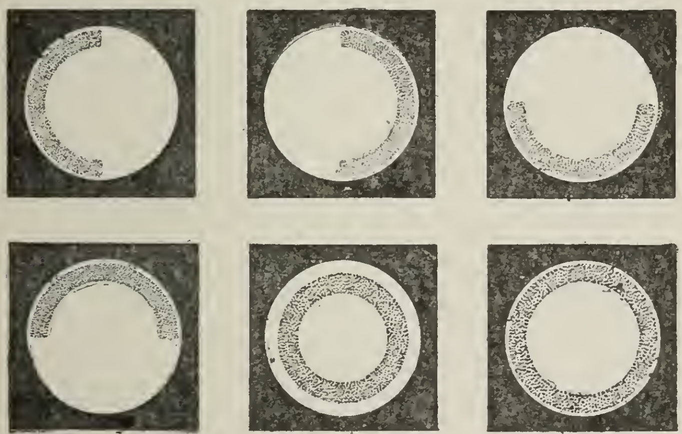
Angle of Carbons. The angle at which the carbons are set will vary with the amount of current used, and to some extent with the size and quality of carbons used. When, looking into the lamphouse, the front wall of the house is brighter below the condensers than above, tip the carbons to a greater angle; or bring them more nearly vertical, when the inner wall of the lamphouse shows brighter above the condensers than below. The same result is attained by rocking the angle of the carbons while watching the screen, and stopping where the illumination is brightest. Care should be taken in practicing with the adjustment to distinguish between the effect on the screen of changing the angle of the carbons and the centering of the arc itself.

For experiment, open the door of the lamphouse, watch the front wall, and draw the arc a little longer; the "brightest spot" on the front wall moves down, because by drawing the arc longer the end of the lower carbon has been drawn from in front of the crater of the upper carbon. To bring this brightest spot back to the condensers, the carbon must be tipped to a greater angle. But the longer arc should not be used unless there is current to support it without breaking. The production of a steady arc, not quite so bright, is evidence of better lamp operating than a brighter but irregular and unreliable arc—a "forced" arc. The amateur always lacks the skill required to force an arc successfully; the master of the lantern is too jealous of his results to practice it. A medium length of arc, steady of feed and steady in illumination, with the angle of carbon to throw the brightest spot of light straight into the condensers, is the proper adjustment. Many lanterns do not have the angle of carbons adjustable without opening the lamphouse.

Centering the Light. The proper burning of the lamp will determine the brilliancy, but its position in the lamphouse will govern the uniformity of the illumination of the screen. There are half a dozen rules for centering the arc, but all of them amount to this: *The screen shows the arc inverted just as it shows the lantern slides inverted, and the brightest spot on the screen must be brought to the middle. If the bright spot on the screen is above the center, raise the arc, for that will lower its image on the screen. If the arc is moved to the right, the bright central portion of the light on the screen will move to the left, correspondingly.* Most lanterns have the vertical adjustment possible without opening the lamphouse, but the lateral adjustment usually requires work inside the lamphouse door. Once correctly adjusted, it seldom requires changing.

In Fig. 10, a shadow shows at the left of the screen, the center of the bright image of the arc is at the right of the center of the screen, and the arc should be moved to the right in the lamphouse to bring the bright spot on the screen toward the left. In Fig. 11, the conditions are reversed, the shadow is at the right, and the arc should be moved to the left to throw the bright spot on the screen to the right, pushing the shadow off the screen. In Fig. 12, the shadow is at the bottom, and the arc in the lamphouse should be raised to lower the bright center of illumination on the screen; in Fig. 13, the shadow is at the top, and the arc in the lamphouse should be lowered to raise the bright center of illumination on the screen.

Focusing the Light. The cone of light passing from the front of the condensers should come to a point at the focal center of the objective lens. The length of this cone may be changed by shifting the light back and forth in the lamphouse, hence the point of the



Figs. 10-15. Guide Chart for Lamp Adjustments

cone may be brought to the lens after the position of the lens has been determined. To find the proper position of the lens, place a slide in the slide holder and move the lens to focus the slide upon the picture screen. Then remove the slide and adjust the lamp to that distance from the condensers which will bring the point of the cone of light to about the middle of the lens barrel. The final adjustment for position of the lamp is determined by watching the picture screen, and the symptoms on the screen are illustrated in Figs. 14 and 15. With a bright margin upon the picture screen (no slide in holder) and with a central shadow or with a ring of shadow or of color about the center of the screen, the lamp is properly "centered" but is too near to the condenser. This is shown in Fig. 14. When the lamp is too far from the condenser, the edges of the screen will be in shadow or show color. This is shown in Fig. 15.

LAMPHOUSE

A sheet-iron house or box contains the lamp and stops its light from blinding the operator and from illuminating the picture screen with the stray rays. The more frequently used adjustments of the lamp are all controlled by knobs upon rods projecting through the rear wall of the lamphouse, rendering possible all adjustments required while a series of slides are being shown, or while a motion-picture reel is being run, without opening the door of the house. The door is at the side and gives access to the lamp for the purpose of renewing carbons and of making such adjustments as ordinarily are required only in setting up the lamp for service. In the door of the lamphouse is a peephole, through which the operator may look at his lamp to determine whether the adjustment is approximately correct before projecting the light upon the screen.

Pinhole Image Peephole. A sheet-iron box an inch or an inch and a half each way with a No. 60 drill hole in the middle of the bottom and the open top placed against the peephole inside the lamphouse door will throw a pinhole image of the arc and carbon ends upon the glass of the peephole. This image will be visible to the operator from any angle, and it is not required that the eye be brought close to the peephole, nor even in line with the peephole and the lamp.

Sliding House. In a projecting machine adapted for motion pictures and lantern slides, the same lamphouse is used for the motion head and for the long-focus lens for fixed slides. With the motion head and the long-focus stereopticon lens mounted upon the projecting stand side by side, the lamphouse is slidable upon a short track so that it may be pushed from the motion head to the stereopticon lens, or pulled back to the motion head. Stops at the end of the track are adjustable, for centering the lamphouse properly upon the motion head or lens at its two positions.

An old arrangement is to have the motion head and stereo lens upon a pivoted platform which swings in front of the lamphouse to bring either the motion head or the stereo lens in front of the lamp.

Ventilation. Openings in the bottom and in the top of the lamphouse permit a current of air to carry away much of the heat of the lamp. A precaution to be observed is that the current of cold air, incoming through the bottom holes, does not strike the face of the condensers, as such a draught may crack the condensers. Wire gauze over the holes in the bottom of the lamphouse will break up the incoming column of air and usually will reduce condenser breakage.

Guard. The top of the lamphouse sometimes gets so hot that a piece of motion-picture film will burst into flames when touched to the house. To prevent accidental contact, the top of the lamphouse may have a guard of wire screen, extending over the edges.

CONDENSERS

The object of these large glasses in the optical system is to get more light into the lens from the lamp. Their efficiency is so great and their cost is so low that all lamp systems use them—indeed, it is thought by operators who have not given their work a thought that projection without condensers is quite impossible. A very good quality of projection is possible without condensers when using a lantern built for use without condensers. Even with a lantern built for use with condensers it is possible to accomplish, in an emergency, a projection which may serve to entertain an audience and save the humiliation of dismissing and disappointing the people altogether.

Development. The development of the condenser as it is generally used today in projecting lanterns is shown in diagrams in

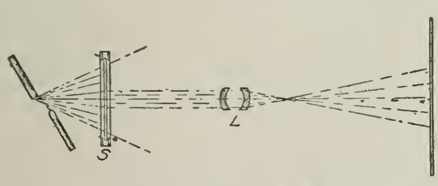


Fig. 16. Development of the Modern Type of Condenser. Double Lens Only

Figs. 16 to 21, inclusive. Fig. 16 shows a system in which the arc lamp at the left throws its rays directly upon the slide at *S*. The rays of the lamp pass through the transparent slide and proceeding then in straight lines pass for the most part outside of the lens at *L*. The lens gets a few of the rays—that small bundle of rays passing through the middle of the slide directly in line from the arc lamp to the lens—and these rays the lens throws into focus upon the picture screen at the extreme right of the diagram. The result is a picture upon the picture screen which covers only a small spot in the middle of the screen and which shows in that spot only a small portion of the slide, the central portion. If only a small slide were used, such as a slide from a toy lantern, in which the entire picture is as large as a ten-cent coin, the entire picture of this diminutive transparent slide at the left would be thrown upon the picture screen at the right. That is one type of projection without a condenser. The slide must be smaller in size than the lens which focuses it upon the screen, so that all the light passing through the slide may find its way into the glasses of the lens. When it is desired to project a slide in which the picture is three inches in diameter (and the usual lantern slide is about that

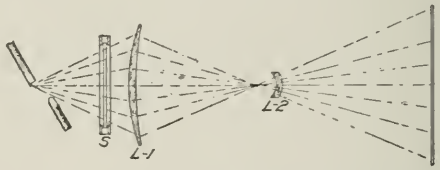


Fig. 17. • Development of the Modern Type of Condenser (Rear Combination of Lens Enlarged)

diameter measured from corner to corner), a very large lens would be required. Notice also that the light after passing through the slide at *S* spreads very rapidly, so that if the lens were placed closer to the slide the lens would not have to be so large in order to catch all of the light passing through the slide.

A modified lens is shown in Fig. 17, which has great light-gathering power without going into the expense of several large glasses. One of the glasses of the lens is made larger than the slide to be projected and is positioned at *L-1* near the slide, catching the rays soon after they have passed through the slide and bending them into the remaining glass of the lens, shown at *L-2*. In this way, practically all of the light of the lamp which passes through the slide is caught by the lens *L-1* and is bent into the lens *L-2* and thus is brought into effect in producing the picture upon the picture screen at the right. The system of this stage of development is further

SCENE FROM PHOTOPLAY, "THE MASTER AND THE MAN"
Courtesy of *Independent Moving Pictures Co., New York*

improved by using the full double lens at the point *L-2*, as shown in Fig 18, the large lens close to the slide being thus made an auxiliary piece of glass, although forming a part of the total lens system. Considered as a glass apart from the lens, and seeking a name for it, it is noticed that it has the power of gathering the light coming through the picture slide and squeezing the rays together or condensing them

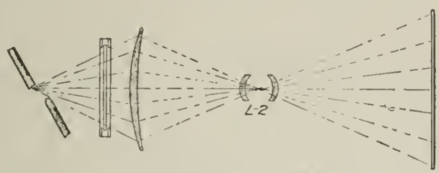


Fig. 18. Development of the Modern Type of Condenser (One Condenser Lens Added)

into the glasses of the main object lens, or lens proper, *L-2*. Considered from that point of view, the name of "condenser" appears to be fitted to the glass in a descriptive way; no one has suggested a better name for it, hence "condenser" it is called.

With the auxiliary lens at its position given in Fig. 18, bending the light after the rays have passed through the picture slide, it is necessary that the lens be of a high grade of glass and that it be very accurately ground, any distortion being noted upon the projected picture at the right. Experiment shows that the auxiliary lens may be placed upon the other side of the picture slide, as shown

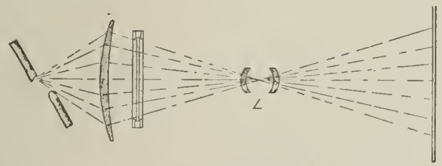


Fig. 19 Development of the Modern Type of Condenser (Condenser Behind Slide)

rearranged in Fig. 19; that in that position it is equally effective in concentrating the light into the lens at *L*, and that when so placed its slight inaccuracies are not so clearly visible in the picture at the right, which is the picture to be viewed by the audience. This permits a condenser to be made of cheaper glass, and with less accurate and less expensive workmanship. With the condenser placed in the position shown in Fig. 19, the condenser may be said to condense the rays into the lens at *L*, but the optical system of the lantern may be better studied and understood, the lantern may be more conveniently analyzed for troubles when something goes wrong, its total adjustment may be more quickly attained and maintained, in short, better work can be done, by considering the condenser as related to the lens, not to the slide, and in considering the condenser as a part of the lens itself, as indeed it is. Consider the lens system as consisting of all the glasses through which the light passes on its way from the arc lamp to the picture screen, and consider that the slide to be projected is inserted into this complete system between two component parts of the lens system.

Condenser a Part of the Lens. Unless the operator gets the mental conception that his condenser is a part of his lens, he is likely to overlook the fact that for good pictures his condensers must be focused into his lens, believing it sufficient that his lens is focused upon the picture slide.

Clip an illustration from a magazine or newspaper, moisten and rub off the printing from the back of the clipping, if printed on the back, and put this clipping into the lamphouse, the picture side against the glass surface of the back condenser. The stereo lens may be adjusted to focus the picture upon the screen. With accurate condensers the image on the picture screen would be sharp, but with cheap condensers it will be much distorted and blurred in some places.

This simple experiment, however, will show that the condensers are a part of the lens systems of Figs. 19, 20, and 21, and as much as they are in the systems of Figs. 17 and 18.

Plano-Convex Condensers in Pairs. Three forms of condensers are shown in Figs. 19, 20, and 21—the *meniscus* in Fig. 19, the *convex* in Fig. 20, and the *plano-convex* in Fig. 21. In each of these systems, the condenser is shown as throwing into the lens all of the light which it catches from the lamp. The more light which the condenser can catch from a lamp of a standard of brightness, the more light will the lens and, therefore, the picture screen receive and, therefore, the more desirable does the particular form of condenser become. The plano-convex condenser—probably because it presents a flat face to the lamp—has the power of picking up more rays of light and of standing the heat of the lamp without breaking better than any other form of condenser of equal price.

The plano-convex condensers are used in pairs, the first of the pair, that nearest the lamp, having the function of bending the rays into parallelism; then they pass to the second condenser which bends them again and throws them into the glasses of the objective lens.

Focal Lengths. The theoretical requirement of the condenser glasses in bending the rays involves glasses of different focal lengths

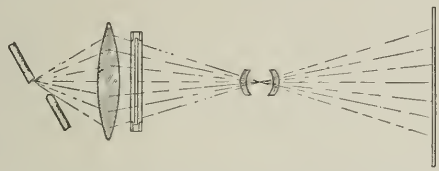


Fig. 20. Development of the Modern Type of Condenser (Double Convex Condenser)

to attain the condition of adjustment in which they will give the most effective results. For theater projection, both for stereo or lantern-slide projection, and for motion-picture projection, this requirement involves the use of a glass at *C-1* nearer the lamp, Fig. 21, of shorter focal length than the glass at *C-2* farther from the lamp, but such is not the practice. The difference in the projected picture upon the screen is slight, and the convenience of using both glasses alike is so great in comparison that the custom of most operators is to use two glasses of the same focal length. In this use, the first lens does not bend the rays quite as much as it should, and they are still slightly divergent between the condenser glasses, resulting in the loss of some

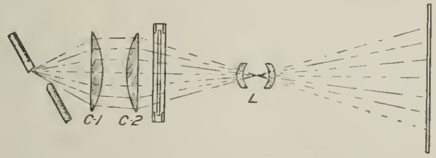


Fig. 21. Development of the Modern Type of Condenser (Present Condenser System)

light around the edge of the second glass, with consequent slight lack of brilliancy in the picture upon the screen.

Theory makes the condenser glass *C-1* of Fig. 21 about six inches focal length, and the condenser glass *C-2* of that figure about two inches longer than the focal length of the stereo lens *L*. Two sixes is the usual combination for service. The condenser has the peculiar feature that any length of condenser glasses will make some sort of projection. The operator who realizes that his condenser is a part of his lens will improve his projection by bringing the two into harmony as far as possible.

Projecting machines are equipped with condensers by the manufacturers and are shipped with fixed distances between condensers and motion head without reference to the focal length of the lens to be used in the motion head, and the focal length of the condenser is not regulated to the length of the stereo or lantern-slide lens nor with reference to the focal length or position of the optical center of the motion-head lens, since neither is known at the factory, the size of screen and the length of throw from the projecting station to the picture screen being unknown. If the condenser lengths are inaccurate, the optical system as a whole may be corrected by determining the proper position of the lamp to bring the rays bent by the condensers to cross at the optical center of the lens, the optical center of the lens being previously determined by focusing a slide upon the screen.

Adjustment for Slides or Motion Head. In a lantern having stereo lens and motion head, the distance from the condensers to the optical center of the stereo lens may be different (probably is different) from the distance between the condensers and the optical center of the motion-head lens. This condition requires that for good pictures the position of the lamp in the lamphouse must be changed each time the lamphouse is moved from motion head to stereo lens, or *vice versâ*. The proper adjustment, when once learned, may be attained by noting the size and the shape of the spot of light around the film window of the motion head, or upon the edges or light guard of the stereo lens.

Emergency Projection. With reference to condensers, emergency projection means projection when there are no condensers available. A cracked condenser is serviceable as long as it holds together—it is better than none. With the motion head, either or both condensers may be cracked, and the picture on the screen will not show it. With the lantern slide and the stereo lens, the back condenser will show its cracks less than the front condenser, but any crack in the front glass will show plainly upon the screen. It is when the condenser glass falls to pieces and drops out of the cell that the operator is required to adopt emergency methods to save the show.

With one condenser gone, put the remaining condenser in the front position—the *C-2* position of Fig. 21—and move the lamp back in the lamphouse until the rays after passing through the condenser cross at the optical center of the lens; if the lamp cannot be moved so far, move it as far as possible. The picture upon the screen will be of the usual size, but of much less than usual brilliancy. If the edges are dim, and a longer lens is available, use the longer lens, thus reducing the size of the picture and increasing its brilliancy.

In the motion head, the stereo lens even may be moved to a position in front of the motion head and the regular motion-head lens removed, projecting the motion pictures through the stereo lens. The resulting picture upon the screen (taking the usual run of motion theaters) would be about four feet wide by three feet high, but bright, sharp, and distinct with the one condenser.

Diffusion Projection. With both condensers lost, use ground glass instead—four sheets, two with the smooth sides together for the back condenser and two with the smooth sides together for the front condenser. They are diffusers rather than condensers, but they will give upon the screen a picture of full size but lacking in brilliancy if the usual objective lenses are retained. The longest available lenses should be used, sacrificing something in size and gaining something in brilliancy.

Adjustment of the Optical System. Select the motion-head lens for focal length according to the lens table, selecting it for the length of throw from the lens to the picture screen and for the size of picture desired upon the screen.

Place a piece of film or a piece of scratched mica in the film window and focus it upon the screen. The lens being a double lens, *i. e.,* a lens tube having glasses at both ends, it may be taken that the optical center of the lens is at the center of the tube

The length of focus of the front condenser glass, *C-2* of Fig. 21, should be equal to the distance from the focal center of the motion-head lens to a point midway between the two condenser glasses. It may be less, rather than more.

The length of the focus of the back condenser glass—*C-1* of Fig. 21—should be about six inches. A longer length of focus will reduce the breakage due to the heat of the lamp, while a shorter length of focus will give a brighter light upon the screen but probably with greater breakage, because the lamp will be brought nearer to the glass.

Push the lamphouse away from the motion head so that the cone of light will pass at the side of the motion head; then adjust the lamp until the cone of light "crosses" just at the side of the motion-head lens and opposite the focal center of the lens. The point where the cone of light crosses is the point where the solid beam of light coming from the condensers reaches its smallest diameter and then begins to spread toward the picture screen. As the lamp is moved forward in the lamphouse, this point of crossing moves forward away from the condensers and toward the picture screen. As the lamp is moved back in the lamphouse, the point of crossing is drawn back toward the condensers. Stop it opposite the focal center of the motion-head lens. Then draw the lamphouse back to the motion-head and notice the appearance of the circle of light about the film window.

The appearance of the circle of light around the film window when the lamp and the optical system are in proper adjustment should be remembered by the operator as a standard. Before opening the film-window shutter to begin projection, the circle of light may be brought to that standard as nearly as the operator can remember it and little or no adjustment will be required to improve the projected picture after the film window is opened.

The optical system having been adjusted to the requirements of the motion head in preference to the requirements of the fixed slide and stereo lens, the process may be repeated for the stereo lens.

Select the stereo lens for focal length according to the lens table, selecting for length of throw and size of picture desired. To produce a picture of comparative size, the length of the stereo lens will be about three times that of the motion-head lens.

Place a slide in the carrier and focus the slide upon the screen. The lens being a double lens, it may be taken again that the optical center is at the center of the tube.

Draw the lamphouse to one side and again adjust the lamp to cause the cone of light to cross at the center of the stereo lens. Notice the appearance of the circle of light, or of the cone of rays as it enters the stereo lens. This appearance may be remembered and will help in making a proper adjustment quickly for the projection of lantern slides.

The cone of light usually is visible in the room by reason of the dust motes floating in the air. If it is not visible for this cause, its formation may be studied and the point of crossing may be determined by holding a white card in the cone of light and moving it toward and from the condenser until the circle of light upon the card is at its smallest, which will be the point of crossing.

It is a great convenience in changing from motion-head to stereo lens if they can be so placed that readjustment of the lamp in the lamphouse will not be required. This can be accomplished by moving the motion head toward or from the lamphouse to bring the focal center of the motion-head lens opposite the focal center of the stereo lens.

A lamp adjustment taken by many operators is that lamp position in which the circle of light upon the film window is reduced to the smallest circle possible which will fill the window. This results in a brighter picture upon the screen in spots, but the distribution upon the screen may be irregular in intensity and objectionable coloring is likely.

THE SLIDE CARRIER

Just in front of the condensers is placed a frame for holding the picture slide. A part of the frame is made to slide, and is provided with windows and grooves for two picture slides. The movable part of the frame is arranged with stops at both ends of its travel so that it will stop with one or the other of its two picture slides in proper position for projection by the lamp and lenses upon the picture screen, the other picture slide being at that time out of the light of the lantern, waiting for the frame to be pushed across into its other position to bring the waiting slide into proper position for projection. The second slide being thus brought into the light of the lantern, the first slide is removed from the carrier and the third slide is put in its place. The carrier then is pushed back into its first position, showing the third slide upon the screen, and so on, the slides being placed in the carrier first at the right and then at the left, the carrier changing ends for each change of picture upon the picture screen.

Simple Form of Carrier. The simple form of slide carrier is shown in the illustration of Fig. 22. The fixed frame comprises a track across the bottom and an open frame at the middle of the track.

Within the frame is shown the slide carrier with its two windows, the carrier being shown slightly out of center.

The carrier has grooves open at the top into which the picture slides are slipped when they are to be projected. Some carriers have a single groove, four inches wide, admitting the American

Fig. 22. Simple Slide Carrier

standard size of slide, which is $3\frac{1}{4}\times4$; in this type of slide carrier it is necessary to center carefully a foreign slide measuring only $3\frac{1}{4}\times3\frac{1}{4}$ that it may appear centered upon the screen when the slide carrier is pushed over. The picture of the American slide is the same size as that of the foreign slide, the additional area being blank margin.

Carriers for American and Foreign Slides. Slide carriers for exhibiting both the American and the foreign sizes of slides may have a pair of centering springs which push either size to the center of the window, or may have two grooves—one wide for the American slide and one narrow for the foreign slide; in the latter case, in showing a mixed set of slides it is necessary to change the focus adjustment of the stereo lens each time the slide changes from one groove to the other.

Slide Window Masks. In Fig. 23 is shown a masked slide window. No matter what the size of the slide placed in the carrier, only

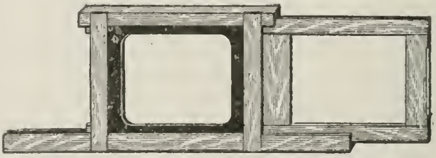


Fig. 23. Slide Holder Window Mask

so much of its picture will be shown upon the picture screen as may be seen through the mask (shown as a black frame) in the slide window.

The slide-window mask is a boon to the operator who cannot make his lens cover his slide. Just put in a mask that the lens will cover. The average set of song slides will be more pleasing with the edges trimmed away by the sharp cut of the slide-window mask than with the corners trimmed away by fading first into color and then into darkness by reason of the failure of the lens to cover the field.

Slide=Window Shutters. When the view upon the screen is changed merely by pushing the carrier across, the old view races off of the screen at a high speed and the new view races on. This is considered objectionable by some people, although it is a matter of opinion whether some of the cures are not worse than the malady.

To cap the lens or to operate a small manual shutter or even a pedal shutter while moving the slide across is the simplest remedy. Devices are offered in connection with complicated slide carriers by which the slide window is closed by an automatic shutter except

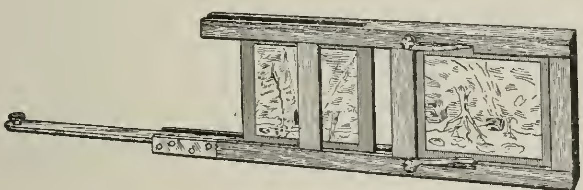


Fig. 24. Slip Slide Carrier

when the carrier is in one or the other of its end positions. By pushing the carrier across quickly, the interval of darkness caused by the shutter becomes very brief. The interval of darkness, no matter how brief, is objectionable, as the pupils of the eyes in the audience begin to expand and again must contract for the succeeding picture, repeating this at every change.

Slip Slide Carrier. In the slip slide carrier, shown in Fig. 24, the slide at the right is in the window for projection and the slide at the left is the new slide next to be projected. The lever and knob at the left engage the new slide and push it into a position in front of the slide already on the screen. Thus both slides are thrown upon the screen in confusion for an instant. The pawls of the controlling handle are released from the new slide when it reaches its position for projection and engage the old slide to withdraw it, so that by the return of the operating handle the old slide is withdrawn, leaving the new one in position in the beam of light. As the old slide is drawn from under the new one, a set of springs presses the new slide down into the position formerly occupied by the old slide, that is, into the position of proper focus for the lens. The change of slides can be made very quickly. A modification of this device carries an opaque shutter which closes the slide window as the new slide comes in and opens it as the old slide is drawn out, thus avoiding the confusion of projecting both slides at once.

Mechanical Slide Changers. Mechanical changers take two forms, which may be classified as *semi-automatic* and *full automatic*. In the semi-automatic type of changer, the object desired is to have the view changed at the desired instant. This is of value in lectures, and in illustrated songs as well. Such a device consists of a spring for drawing the carrier across, with a lever for setting the spring to tension, and an electromagnet for releasing the carrier. The operator in the projection room places the new slide in the carrier and sets the spring to tension to draw the carrier across. When the lecturer desires to have the new slide projected he touches a push button or electric switch which releases the slide and the spring draws it across. The operator at the lantern then replaces the old slide with the next of the series, sets the spring to draw the carrier back, and again waits until the lecturer has released the carrier electrically. In the case of the illustrated song, the stage director, the orchestra leader, or the pianist would change the slides by the push button.

For the dissolving lantern the operator changes the slide in the dead lantern and sets the dissolving shutter to tension. The control exercised electrically by the lecturer or musician then releases the dissolving shutter to change quickly to its other position, making the quick shift from slide to slide.

In the full automatic changer, the slides are placed in a rack containing a space for each slide, and this rack or multiple carrier is stepped forward, step by step, either under control of the projection operator, the stage director, or a musician in the orchestra. The rack for holding the slides in the full automatic changer takes the form of a wheel with the slides on the edge, a chain with the slides in the links, or of a nest of carriers in which slide after slide is brought into an operating position and then forced into position in the beam of light for projection. Full automatic changers are much used in windows and in public places for the projection of advertising slides, the changes being controlled by clockwork.

Storage of Slides. Sets of song slides come packed in small wooden boxes, and between repetitions of the song they lie stacked upon the operator's table, lying close upon each other, with no opportunity to lose the heat of the lamp acquired while being projected, and getting hotter every time the set is run through the lantern. Occasionally one or more are knocked from the table and the set is run a slide or two short thereafter, either the operator or the theater manager paying for the breakage. A slide storage-box like that shown in Fig. 25, but preferably with the hinges taken from the lid so that the lid may be removed completely while operating but replaced when desired, will keep the slides in order, prevent accidental breakage, prevent the insertion of a slide in the carrier in reversed or inverted position, and give the slides a chance to cool between successive projections. The announcement slides are kept in one end, the song slides in the other. The cost of one good slide or two cheap slides is about the price of such a box.

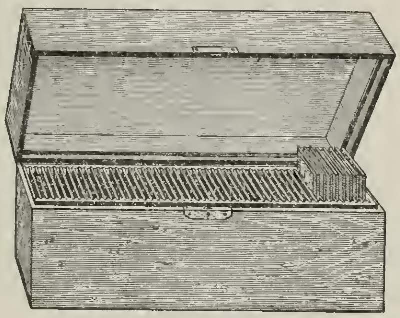


Fig. 25. Slide Storage Box

DISSOLVING LANTERNS

Up to the time of the introduction of the motion picture, the dissolving lantern was the most interesting of all optical illusions, and a favorite means of entertainment. It was developed to such refinement of detail that motion in projected pictures was well simulated in many instances. Entire scenes were played through with the very complete sets of lantern slides made and used with multiple lanterns, some sets of pictures requiring four or six lanterns working simultaneously upon the screen to produce the effects as planned.

Triple Lantern. In Fig. 26 is reproduced an illustration taken from an old book upon the subject of the optical lantern. It shows a triple lantern, three lanterns built in one, with tubes and dissolving valves at the back for the oxy-hydrogen or lime light. It was with such lanterns as this that truly "dissolving" effects were produced.

Imagine a rural scene, showing woodland, meadow, and lake. It is winter, and winter with a single lantern, winter with a single slide. By an auxiliary slide, in the same lantern, skaters appear

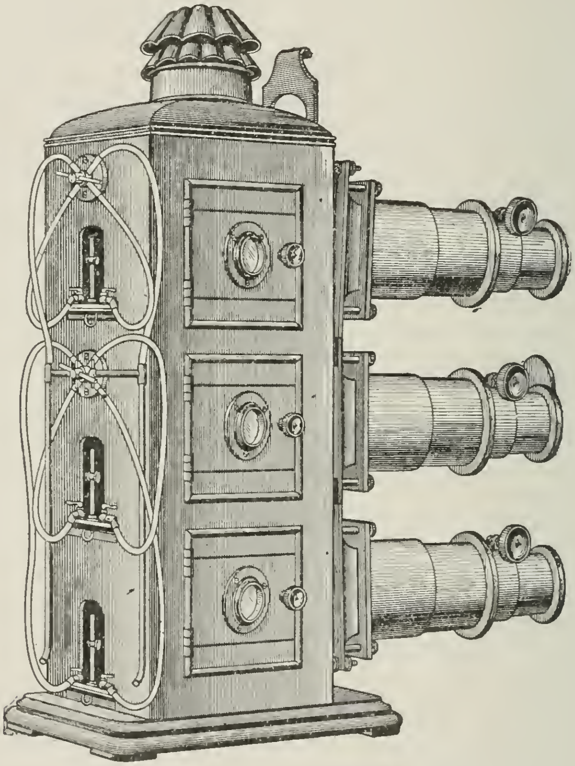


Fig. 26. Triple Lantern for Dissolving Projection

and glide over the surface of the little lake. The skaters pass off the side of the picture and the scene again is still, with a single lantern. Now the picture begins to darken; soon only patches of snow are left here and there. The view has been dissolved from the first lantern used to another lantern with a slide similar and registering exactly but with less snow. Two or three or more successive slides are dissolved each into the next of the set before the snow is entirely gone and the view remains in the neutral colors of March, but with, yes, at first it seems elusive, but surely there is a suggestion of green in the meadow, positively now, and the darker green of the meadow is supplemented by a lighter green in the treetops. The branches begin to lose themselves in the mass of growing foliage, all in full color, and summer is here. How many slides have been used in the change is known only to the men behind the machines at the projection station; the audience, apparently, has seen but one lantern slide, but one view, in which not a tree nor house nor post of fence has moved, yet a view which has changed before their eyes in a manner even more wonderful than the changing of the modern motion picture, whose flicker betrays at once its mechanism and its origin.

In the summer scene (from one lantern) the lake is no longer ice and a white swan (from a second lantern) glides upon its surface. Clouds begin to appear in the sky (dissolving the view from the first lantern into a third lantern while the second lantern holds the swans moving upon the lake). The swan disappears and lightning begins to flash (from the swan's lantern), the rain begins to fall (view from the third lantern, rain from the first lantern, lightning from the second lantern), the clouds move across the sky (mechanical attachment for the third lantern), and the storm rages, as with the modern motion-picture film, sheet-iron thunder, bean-bag rain, and wind drum, complete.

The lightning ceases, lights appear in the windows of a house; presently the rain ceases and the clouds begin to break, and by and by the view dissolves into a moonlight scene with drifting clouds, ultimately giving a clear sky, moonlight sparkling on the surface of the lake, etc.

A notable set of slides showed the burning of a building, the breaking out of the fire, the arrival of the fire brigade, etc.

From this origin and from this field of activity comes the dissolving lantern of the song slide set, where its duty now remains solely to shift from one slide to some other probably quite unlike it, the dissolving function of the lantern being operative merely to save the eye of the spectator from the shock of other methods of change.

The Double Lantern. The modern dissolving lantern consists of two lamphouses, most conveniently mounted one above the other, although the arrangement of having them side by side has been tried. Each lamphouse is equipped with lamp, condenser, and lens system, slide carrier, and a shutter. The two shutters of the two lanterns are operated by a single handle and are so arranged that as the handle is moved one shutter is gradually closed and the

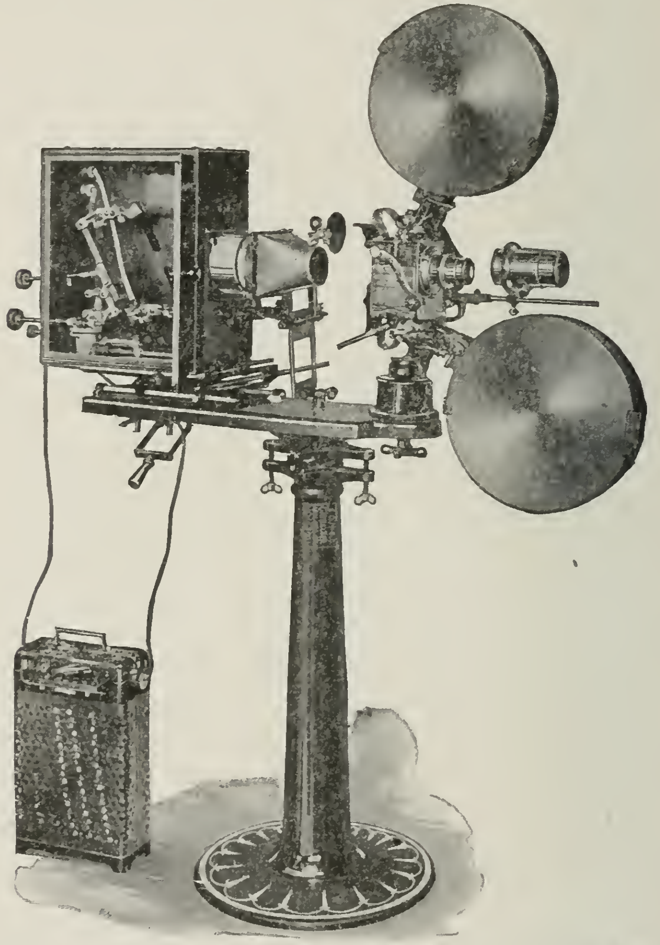


Fig. 27. Combination Projector, for Motion and Fixed Pictures, with Single Lantern

other gradually opened. If in connection with a motion head, the lower lamphouse is arranged to slide for the stereo lens or for the motion head, the upper lamphouse being fixed in position. Slides are projected successively by placing the first slide in the lower carrier, the second in the upper. The first projection is made from the lower lantern, the handle is shifted to change the shutters, the slide is changed in the lower lantern and the handle again is moved to change the shutters, when the slide in the upper carrier is changed. The slide carriers in such lanterns may be of simpler or more convenient form than in the single lantern. The pictures projected by the two dissolving lanterns should be of the same size and carefully lined up

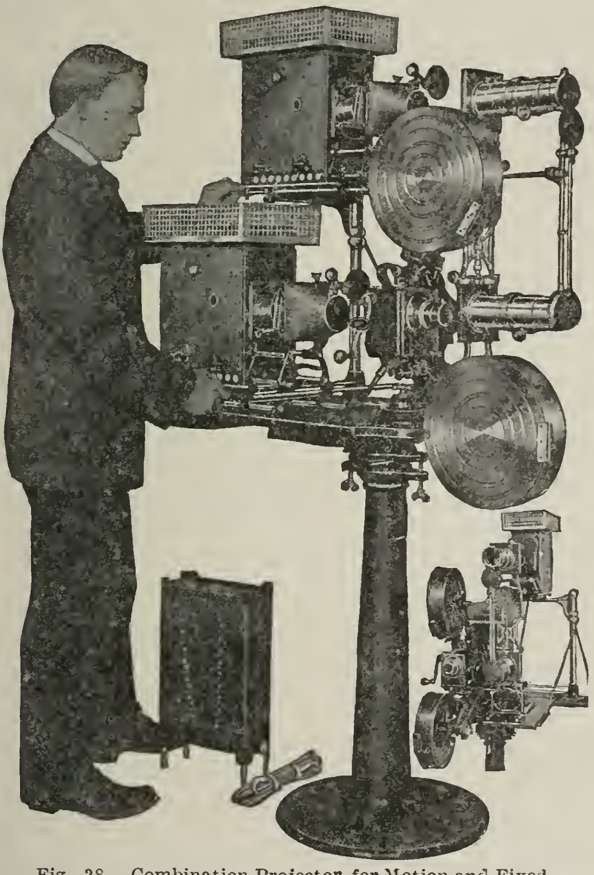


Fig. 28. Combination Projector, for Motion and Fixed Pictures, with Double Dissolving Lantern

together upon the screen. Modern single and double lanterns for motion head and dissolving slides are shown in Fig. 27 and Fig. 28.

Lining Up the Double Lantern. In setting up the projecting lantern with motion head, care should be taken to bring the two pictures into approximately the same position upon the screen, although the pictures from the motion head and from the stereo lens will be of different shape and may be widely different in size unless the lenses are carefully matched. In setting up the dissolving lantern the two pictures from the lanterns should coincide just as accurately as it is possible for the operator to make them. Adjustment screws will be found on the upper lantern for this purpose.

Alignment Masks. Considering the inaccuracy of slide masks in commercial sets of song slides, it is impossible to secure perfectly the desired result in dissolving without slide-window masks, such as shown in Fig. 23. With two such masks, cut from thin, ferrotype iron, or any thin sheet metal, of the same size and shape, and with two stereo lenses matched to exactly the same focal length (the lens makers will sell two matched lenses for an extra charge for matching), it is possible to dissolve without slides from one lantern to the other without showing any change in the edges of the white field of the screen. With this arrangement, good effects will be obtained with dissolving slides which are large enough to fill the windows.

Dissolving Shutters. The dissolving shutters should be set to close each lens half when the lever is in the middle of its travel. The light should be cut off just in front of the lens, near the lens, preferably with a shutter having a saw-tooth edge operating from one side with a horizontal movement across to the other side. The shutters, having two wings which cut off the edges of the lens first, leaving the middle of the lens effective until the last, and also the iris shutters which work between the lens glasses, inside the lens tube, and shut off the light beginning with the outer edges and gradually narrowing it down to a smaller opening in the middle of the lens until finally the light is stopped altogether, are fallacious in theory, for this reason: By such shutters, the volume of the light is reduced but the definition of the fainter image upon the screen is increased. With the shutter two-thirds over, the new image has twice the brilliancy, but the old image has greater definition—an objectionable feature. In the simpler cut-off working from one side only, the definition is impaired as the volume of light is diminished and the vanishing picture fades away in a blur which the eye cannot follow, the eye acting to pick up the new picture as soon as that picture has the greater light volume, it having also from that time the greater sharpness of definition as well.

SCENE FROM PHOTOPLAY, "THE CARDINAL'S EDICT"

THE INTRIGUE IS DISCOVERED AND THE GUILTY ONES EXPOSED
Scene from Photoplay, "The Red Domino"
Courtesy of *Great Northern Film Company, New York*

Equipment of the Second Lantern. The second lantern, or upper lantern of the double lantern, should be complete and as far as possible separate from the lower lantern. Positively it must have a rheostat separate from that of the motion-head lantern, with separate switch for opening its electric leads and separate wiring from the switch through the rheostat to the lamp. Obviously, the lower lantern may be called upon for use in the ordinary way for motion and fixed projection without dissolving, in case the upper lantern is out of order, or the supply of carbons runs short; it is advisable also to have the upper lantern complete for similar use alone, removing it from its higher position to the lower. The lower lantern should have the double-slide carrier which it would require if the upper lantern were not used.

Operation of the Double Lantern. With electric lamps in the lanterns, the lamps are burned all the time of dissolving projection, since the striking and regulating of the arc requires too much time to be repeated for each new slide. During the projection of a roll of film with the motion head, the upper lantern may be cut out, striking the upper arc again while the lower lantern is projecting an announcement slide or a song title slide through its stereo lens. The upper lantern requires the same care as the lower, and its condensers should be identical with those of the lower lantern, adjusting it to match the lower lantern in every way. With condensers of the same focal length, the lamp must be adjusted to give the same appearance of the circle of light upon the back of the stereo lens tube. The rheostat of the upper lantern must have the same resistance as that of the lower lantern, and should be of the same construction to have the same radiating capacity. The same class of carbons should be used for the two lanterns, and the carbons should be set at the same angle.

Single-Lantern Dissolvers. If the perfect single-lantern dissolver has been produced, it at least has not come into general use. The object of the single-lantern dissolver is to fade the picture screen from one picture to another in the manner in which the double lantern dissolves a view into a dissimilar one (no reference to the older *art* of dissolving), the result being accomplished with a single lamphouse. The slip slide carrier is a compromise effort in this direction.

A promising dissolver for single lanterns is arranged as follows:

The slide carrier is moved forward from the condensers until a separation of about three inches is attained; then a forty-five-degree mirror is mounted slidably between the condensers and the carrier to reflect the beam of light toward the ceiling, a second slide holder and second objective lens are arranged in the vertical beam of light, and a second mirror is arranged above the vertical objective lens to reflect the beam of light toward the picture screen. The first slide being projected by the lower or horizontal lens, the second slide is placed in the holder of the vertical system and the mirror is slid in to transfer the beam of light from the slide of the horizontal to the slide of the vertical lens system. Shutters are not required for the lenses. This gives the effect of changing pictures by moving a vertical line across the picture screen from side to side, the old picture disappearing before the line and the new picture appearing after the line.

A modification is the substitution of a piece of polished clear plate glass for the mirror, leaving it always in its reflecting position when projecting lantern slides, whereby the light of the lamp is divided between the horizontal and the vertical lenses of the system. With this arrangement, a pair of dissolving shutters may be used and the fading of the entire view at once into the next view is obtained as with the double lantern.

Precautions in Dissolving. With the electric arc as a lamp, and with both arcs burning all the time during the exhibition of a series of views, the only danger to the picture screen is the projection of ludicrous combinations of two views, either successively shown or during the interval of superposition, when both are upon the screen together.

Reversals. The slides must be put into the carriers right side up (which is "head down" in the carrier), for an inverted slide is just as comical in the dissolving lantern as anywhere else. A "reversed" slide, however, may be rather more comical in a dissolving lantern than in a single lantern. By "reversed" slide is meant a slide which is put into the slide carrier "head down" but with the wrong side of the glass turned toward the lamp, reversing the picture on the screen right for left. With the same scene on two successive slides, probably with a change only in the position of the figures, as frequently occurs in song slide sets, dissolving one scene into the other with one of the slides reversed produces the crazy effect of a prominent feature of the scenic setting disappearing from one side of the scene and appearing simultaneously on the other side, every fixed detail of the scene changing places similarly, as though the scene were upon a revolving stage acting under control of some magician's wand. This is avoided easily by arranging the slides properly in their boxes before starting the series.

Slide Alignment. Where two slides follow each other with the same scene setting, the slides apparently having been made from negatives made without changing the position of the camera, it is desirable to bring the two views into alignment so that the trees and the other fixed objects will not be "doubles" on the screen during the act of dissolving. Knowing this particular feature of the two successive slides, the dissolving shutter may be opened upon the second slide so slightly that the audience will not note the coming of the new picture, yet the operator may be able to note some particular visible detail and bring the new picture into alignment with the old by moving the slide carrier of the new slide. Then proceeding with the dissolving shutter very slowly, the figures of the scene alone changing slowly and the fixed objects remaining upon the picture screen as though but one slide were being shown, the effect is delightful and well worth the effort required to attain it. It is a step toward bringing to life again the old art of the dissolving lantern.

The operator who desires to attain this effect and who fortunately has a set of slides with two slides in it capable of the effect, always can secure the required alignment by gluing bits of paper, card, or match sticks to the top edge and to the side edge of one or the other of the slides, carefully bringing them into alignment upon the screen before showing the set before an audience. In this case, the slide arranged for the lower lantern in the preliminary alignment must be projected from that lantern when the effect is desired, for it is most unlikely that the two lanterns themselves will be so perfectly adjusted as to permit the slides to be projected interchangeably from the two carriers and get the proper alignment for dissolving in both cases.

The utter extinction of the old art of the dissolving lantern is much regretted. Slide makers as well as lantern operators are to blame, the makers either forgetting the subject altogether, or taking for granted that the operators do not know how to dissolve.

Many sets of song slides show a face in a flower, in a bouquet, or in a medallion, or some fixed setting equivalent to a frame. A slide showing the bouquet without the face, dissolved skillfully into a slide showing the bouquet or other device with the face, would please the audience. Just for the simple reason that it would please the audience, the theater manager would like to have it and the slide maker should offer it. Sets of slides (plebeian song slides) especially made for the dissolving lantern (and the skillful operator) should be offered by the slide manufacturers. The construction of such a dissolving set, by slides additional to the usual set, and made at the same time, and added to the set when used for the dissolving lantern, will add to the interest of the show and the reputation of the slide maker; let the theater manager demand them and the demand will be met by the manufacturers.

Speed of Change. The easiest method of control which the operator has in a set of slides is the speed at which he throws over the dissolving lever. This speed controls largely the dissolving effect upon the screen. By carefully watching the matter of lever speed, the change from the old slide to the new one in many instances may be made pleasing or ludicrous.

Where the change between the two slides is in the figures only and the scene setting can be brought into alignment, a very slow change produces a pretty effect. Where the change is from a scenic view to a single object in detail, as from a woodland scene to a bouquet, either with or without the usual framed face, the slow change is pleasing. Entirely dissimilar views sometimes unite in unexpected combinations which are pleasing and which may be offered to the audience by the slow movement of the change lever.

Entirely dissimilar views sometimes unite in unexpected combinations which are ludicrous in the extreme; two moons in one sky, or a white horse and buggy upon a parlor sofa, are not commonly seen except upon the picture screen with a dissolving lantern and a thoughtless operator. In a case of this kind, make a swift change by a quick movement of the dissolving lever, or change the order of the slides in the set. In a lecture, the order of the slides can not be changed. In an illustrated song, the slides sometimes are so characterless and so meaningless, that the rearrangement of a few of them, or the omission of a few of them, is quite permissible.

THE MOTION-HEAD LANTERN

The lantern is not different, but its method of operation has a requirement additional to that of a lantern used for fixed slide projection only. The motion-picture film image being but one-tenth the area of the fixed slide, and the picture on the screen being required to be about the same size, the motion-picture film must have ten times the intensity of light to stand the increased magnification. An increase in light intensity is effected by putting the film in a more condensed portion of the cone of light coming from the condensers, but it remains a fact that fixed slide projection may be accomplished satisfactorily with a less brilliant arc than that required for the motion picture. To state it the other way about, the motion-picture arc must be a hotter arc than that actually required for fixed slides, and the motion-head lantern must furnish a stronger light.

Having the strong light for the motion picture, it is easy to use it for the fixed slides, and it is customary so to do. It is customary also to break announcement slides with the excessive and unnecessary heat. Take note that the motion-picture film is exposed to the heat of the arc for about one-fourteenth of one second, while the announcement slide is on the screen and exposed to the heat of the arc from ten seconds to a full minute or even more.

The motion-head lantern equipped with an auxiliary rheostat, or with an auxiliary switch for an adjustable rheostat, will save money by using less electric current and will save money also by requiring fewer new announcement slides to replace the slides broken by the unnecessary heat of the motion-head arc.

With direct current, fifteen amperes is sufficient current for the projection of a fixed lantern slide upon a picture screen less than fifteen feet wide; for the same screen the motion-picture projection should use thirty to forty amperes. With only alternating current supplied from the power mains, the currents used by the lamp will be greater, running to sixty amperes for the motion-picture arc, but the proportion will remain.

Auxiliary Rheostat. Two rheostats may be wired into the same lamp circuit, the first one of them as usual and the second one with a short-circuiting switch or shunting switch placed handy to the operator when standing at the projecting machine. The second rheostat being shorted by the switch, the first rheostat is adjusted to give the current required for the motion-head arc. The shorting switch then is opened and the second rheostat is adjusted (leaving the first as it was) so that the two together give a sufficient current for the projection of lantern slides, using probably not more than one-third and certainly not more than one-half the current required for the motion-head work. Thus adjusted, the motion head always is run with the shorting switch closed and the fixed slides always are projected with the shorting switch open.

The arrangement of circuits with two rheostats is shown in circuit diagram in Fig. 29. At the extreme left are shown the street mains of the electric circuit, appearing as two vertical lines *SM*. Branch wires pass from the street mains to the lamp *L* at the right

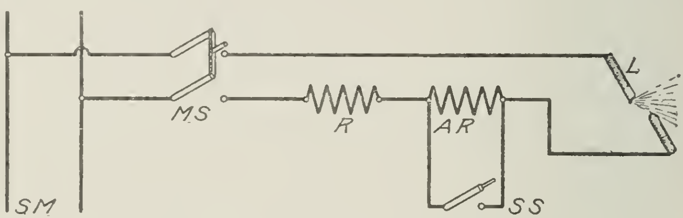


Fig. 29. Connections for a Single Lantern with Two Rheostats

and in this pair of branch wires or lamp leads are included first the main switch *MS* and then the two rheostats *R* and *AR*, the auxiliary rheostat *AR* being provided with a shorting switch *SS* whose blades are connected to the terminals of the auxiliary rheostat. In operating, the switch *SS* is closed and the rheostat *R* is adjusted for the motion arc; then *SS* is opened and the second rheostat *AR* is adjusted to cut the current down for the song slides, fixed slides always being shown with the switch *SS* open.

Auxiliary Rheostat for the Double Lantern. When the double lantern is used for motion pictures and dissolving slides, it will be seen that the upper lantern never is used for the motion head. It will not require the adjustable-current feature. A wiring diagram for a double lantern for motion head and dissolving slides, equipped with the current-saving rheostats, is shown in Fig. 30.

At the left, Fig. 30, the vertical pair of lines represents the street mains for the electric-power circuit. From these street mains a pair of wires is taken to two double-pole knife switches, one switch for each of the two lanterns. From the lower knife switch the circuit extends to the right to the lamp of the lower lantern, passing through the two rheostats *R* and *AR*, and the shorting switch is connected to the terminals of the auxiliary rheostat *AR*, as it was in Fig. 29. With the upper lantern, however, it is necessary to balance the current against the lower lantern when the shorting switch *SS* is open. To show that balancing in the diagram, two rheostats are shown in the circuit of the upper lamp, but the shorting switch is not required, as the upper lamp is used for slides only. A single

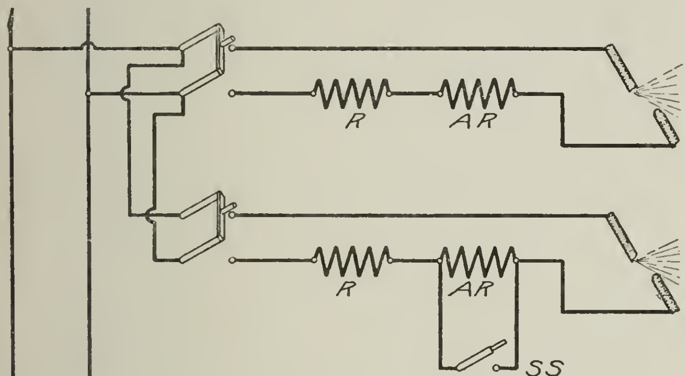


Fig. 30 Connections for a Dissolving Lantern with Two Rheostats

rheostat will be sufficient for the upper lamp if it is capable of being adjusted to a resistance to balance the two rheostats of the lower lamp.

Auxiliary Switch. Another arrangement for saving current and condensers and also for improving the quality of the exhibition, by reducing the heat of the lamp for slides, is that of using both parts of an adjustable rheostat in the sense of the two rheostats shown in Figs. 29 and 30.

Fig. 31 shows an arrangement in a circuit diagram for a single lantern using two values of resistance from one adjustable rheostat, and Fig. 32 shows an arrangement of the same nature for the double or dissolving lantern when one of the lanterns is to be used for motion head also. In Fig. 31, the street mains are shown vertically at the left; from the street mains the lamp lead is taken to the knife switch on the power board, and from the knife switch through the adjustable rheostat to the lamphouse and lamp. The method of connecting the rheostat is the one usually used, carrying the circuit to the lamp-

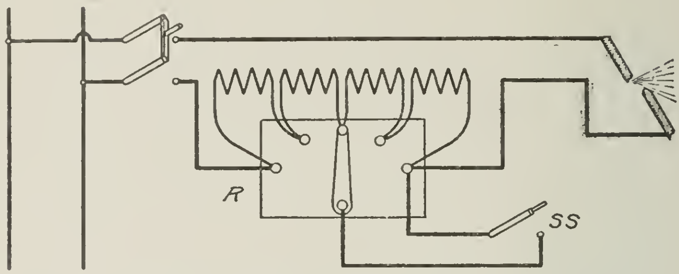


Fig. 31. Connections for an Adjustable Rheostat and Auxiliary Switch with a Single Lantern

house through all of the wire of the rheostat and then short-circuiting as much of the rheostat wire as is not needed. The shorting may be done in the rheostat either by a movable handle, as indicated in Fig. 31, or by a short connecting wire between posts or terminals on the

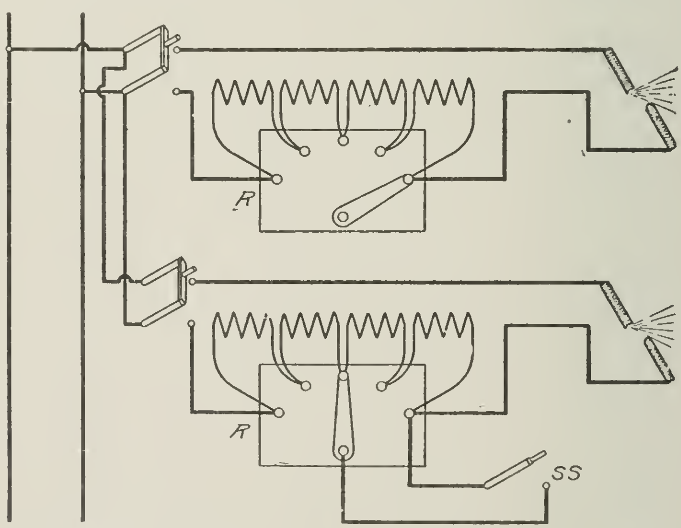


Fig. 32. Connections for an Adjustable Rheostat and Auxiliary Switch with a Dissolving Lantern

rheostat. This method of connecting a rheostat has the advantage of giving a continuous circuit through all of the wires of the rheostat in case the short-circuiting arm of the device makes a defective contact, or in case the short-circuiting bridging wire is accidentally broken or disturbed. Not only is the projecting possible in case of such an accident, but there is the further advantage that disastrous arcing will not occur at the rheostat because the break will be shunted by the rheostat wire. With this method of connection of the rheostat into the lamp circuit, either in the case of the arm type of device or of the bridging wire type, the short-circuiting conductor of the rheostat is cut and is taken by extension wires of sufficient size to carry the full current to the short-circuiting switch *SS* which is at the operator's hand as he stands at the projecting machine. By closing the shorting switch *SS*, the coils of the rheostat are short-circuited and the current has the full value intended for motion-head work according to the adjustment of the rheostat, but when the shorting switch *SS* is opened, then the rheostat has the short taken off of the coils which had been cut out, and the full resistance of the rheostat is effective upon the lamp circuit, cutting the current down to a proper amount suitable for use with slides without endangering them by excessive heat.

The arrangement for the double lantern is shown in circuit diagram in Fig. 32. The lower lantern is equipped exactly as is the lantern shown in diagram in Fig. 31, but the upper lantern has the full resistance value of the rheostat always in its circuit, thereby equaling the adjustment of the lower lantern when the shorting switch is open, no switch being used with the upper lantern. Only two rheostats are required for the lanterns, and they should have the same resistance that they may balance each other for the song slides and other dissolving pictures.

THE LENS

The projecting lens should be anastigmatic, rectilinear, and achromatic. It should reproduce upon the picture screen the image of the lantern slide with the least possible degree of distortion, or with a negligible amount of distortion of the picture.

Lens Corrections. The usual lens for stereopticon projection is the Petzval type, an achromatic, rectilinear lens of four glasses, the two glasses of the front end of the lens tube being cemented together and the two of the back end of the tube being held apart by a spacing ring. Fig. 33 shows the shape of the glasses used in this lens. The double end, with the two glasses and the spacing ring between, always should go next to the slide, and the single end toward the picture screen.

With the Petzval lens, and with all astigmatic lenses of any type, it is impossible to get a sharp focus over all of the picture screen at the same time. The peculiarity of the focus of the astigmatic lens is that the picture sometimes presents streaks radiating from a common point and at other times presents large arcs around a common point. The focus seems to be sharp only in a center spot or in a ring surrounding a center spot. In some slides the defects of the astigmatism of the lens can not be noticed, while in others it is prominent. Slides with sharp points of light show the defect more promi-

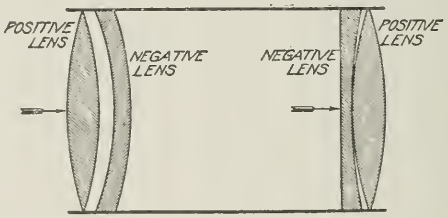


Fig. 33. Section Through the Glasses of a Projecting Lens of the Petzval Type

nently than slides having only lines, while slides showing scenes without sharply cut features near the edges will not show the astigmatism at all. In any picture projected with the astigmatic lens the corners must be sacrificed to improve the central portion of the view, for the astigmatic lens usually is a cheap lens and lacks in angle of view as well as in the correction for astigmatism.

An achromatic lens is one which will project white light without making color fringes along every sharp edge between light and shadow in the picture. White light is composed of many colored rays, and a single piece of glass, such as a glass prism, will separate the colors. The cheapest form of lens also will separate the colors, as may be seen with a cheap reading glass which colors the edges of black letters upon a white sheet. The projection lens must keep the lines clear of colors. Do not blame the lens for coloring which is due to the arc being out of adjustment. Coloring in the pictures caused by lack of adjustment of the arc will color the whites of the picture in blotches, while a poor lens will give a clear white in the middle of a large white area but will color the edge where black meets white in a sharp line, particularly toward the margins of the picture.

A rectilinear lens is one which will project a straight line of the slide as a straight line in the picture on the screen. The straight line of the mask or edge of the picture of the slide is a line coming under this rule, and a rectilinear lens is required to give straight edges to the picture. Rectilinear lenses have their glasses separated into two groups, as shown in Fig. 33, for the Petzval form of lens, one group of glasses being mounted in the front end of the lens tube and the other in the back end, and each of the two groups having two glasses to give achromatic correction.

The next consideration in the projection lens is the angle of the cone of light which it will handle. This requirement rises from the fact that the slide is not always placed centrally with the axis of the lens. Its manifestation on the picture screen usually takes the form of dark corners at the two lower corners of the picture. When the axis of the lens is shifted to correct the corners, the sides of the picture become inclined toward each other, even with a rectilinear lens, and the "keystone" picture results. In addition to being achromatic, rectilinear, and anastigmatic, therefore, the projection lens should have a sufficiently wide angle to bring up the corners of the picture without giving the picture the keystone shape to such an extent as to be objectionable. Even the cheapest lenses for projection purposes are rectilinear and achromatic; anastigmatic and wide-angle lenses may be had if one wishes to pay for them.

Lenses for Given Requirements. To select a lens for the projection of lantern slides in a particular theater requires that the distance from the picture screen to the projection machine, called the "length of throw," be measured, and that note be taken of the offset distance of the projection machine, *i. e.*, the distance to the side or toward the ceiling from the line of the center of the picture on the screen.

If the distance from a horizontal line from the middle of the picture on the screen, measured from the lens to the line, is not greater than one foot for each ten feet of throw, it is likely that a good picture will be secured with a narrow angle lens. That is, for example, as follows: Where the screen is vertical, either upon a wall or on a drop curtain of a stage, the point of the middle of the picture probably will be slightly above the middle of the screen, because the top of the picture will be thrown to the top of the screen, the bottom of the picture being above the bottom of the screen. With the projection machine in the middle of the house at the rear, facing the screen, then the height of the middle of the picture on the screen may be compared with the height of the lens of the projection machine. Usually the lens of the projection machine is above the height of the middle of the picture on the screen. Now with a sixty-foot throw and the lens more than six feet higher than the middle of the picture, there will be a compromise between a sharp picture and a keystone picture unless a wide angle lens is obtained. With a throw of one hundred feet, the lens may be ten feet higher than the middle of the picture before the trouble becomes aggravated. With short throws from an elevated position in the room a very wide angle of lens should be obtained if possible. The feature of the lens angle is illustrated in a diagram in connection with the focusing of the picture upon the screen. The requirement of greatest prominence, and sometimes the only requirement considered in selecting a lens, is the length of the lens focus.

Length of Lens Focus. For the purposes of the projecting stereopticon, the length of focus of a lens may be defined as *the distance from the center of the lens tube to the lantern slide when the slide is in focus upon the screen;* but the real focal length is just a little shorter, and the focal length is determined by the length of throw and the size of the picture required upon the screen, the lens being properly adjusted to the slide distance afterward.

The focal length of a lens may be measured also by focusing the image of the sun upon a card and measuring from the middle of the lens to the card, or by focusing the light of a distant window upon a white card until the lines of the window are sharp and then measuring the distance from the center of the lens tube to the card. The lens length required for lantern slides for a given theater is most easily obtained from a lens table.

Lens Table. Table I gives the size of the picture upon the screen for different lengths of lenses and different lengths of throw, when lantern slides are projected. At the left is given the lengths of the different lenses considered, from 5 inches to 24 inches. The columns at the right of the first column are arranged each for a

TABLE I

Size of Screen Image When Lantern-Slides Are Projected

Size of Mat Opening 2¾ by 3 Inches

Equiv. Focal Length of Lens Inches	Length of Throw												
	15 ft.	20 ft.	25 ft.	30 ft.	35 ft.	40 ft.	45 ft.	50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.
5	8.0	10.8	13.5	16.3	19.0								
	8.8	11.8	14.8	17.8	20.8								
5½	7.3	9.8	12.3	14.8	17.3	19.8							
	7.9	10.7	13.4	16.1	18.8	21.6							
6	6.6	8.9	11.2	13.5	15.8	18.1	20.4						
	7.3	9.8	12.3	14.8	17.3	19.8	22.3						
6½	6.1	8.2	10.4	12.5	14.6	16.7	18.8						
	6.7	9.0	11.3	13.6	15.9	18.2	20.5						
7	5.7	7.6	9.6	11.6	13.5	15.5	17.5	19.4					
	6.2	8.3	10.5	12.6	14.8	16.9	19.0	21.2					
7½	5.3	7.1	8.9	10.8	12.6	14.4	16.3	18.1					
	5.8	7.8	9.8	11.8	13.8	15.8	17.8	19.8					
8		6.6	8.4	10.1	11.8	13.5	15.2	17.0	20.4				
		7.3	9.1	11.0	12.9	14.8	16.6	18.5	22.3				
8½		6.2	7.9	9.5	11.1	12.7	14.3	16.0	19.2				
		6.8	8.6	10.3	12.1	13.9	15.6	17.4	20.9				
9		5.9	7.4	8.9	10.5	12.0	13.5	15.1	18.1	21.1			
		6.4	8.1	9.8	11.4	13.1	14.8	16.4	19.8	23.1			
9½		5.6	7.0	8.5	9.9	11.4	12.8	14.2	17.1	20.0			
		6.1	7.6	9.2	10.8	12.4	14.0	15.5	18.7	21.9			
10		5.3	6.6	8.0	9.4	10.8	12.2	13.5	16.3	19.0	21.8		
		5.8	7.3	8.8	10.3	11.8	13.3	14.8	17.8	20.8	23.8		
12			5.5	6.6	7.8	8.9	10.1	11.2	13.5	15.8	18.1	20.4	
			6.0	7.3	8.5	9.8	11.0	12.3	14.8	17.3	19.8	22.3	
14				5.6	6.6	7.6	8.6	9.6	11.6	13.5	15.5	17.5	19.4
				6.2	7.3	8.3	9.4	10.5	12.6	14.8	16.9	19.0	21.2
16					5.8	6.6	7.5	8.4	10.1	11.8	13.5	15.2	17.0
					6.3	7.3	8.2	9.1	11.0	12.9	14.8	16.6	18.5
18					5.1	5.9	6.6	7.4	8.9	10.5	12.0	13.5	15.1
					5.6	6.4	7.3	8.1	9.8	11.4	13.1	14.8	16.4
20						5.3	6.0	6.6	8.0	9.4	10.8	12.2	13.5
						5.8	6.5	7.3	8.8	10.3	11.8	13.3	14.8
22							5.4	6.0	7.3	8.5	9.8	11.0	12.3
							5.9	6.6	7.9	9.3	10.7	12.0	13.4
24								5.5	6.6	7.8	8.9	10.1	11.2
								6.0	7.3	8.5	9.8	11.0	12.3

different length of throw, the length of throw being mentioned at the top of the column.

With each length of lens there are two figures for each length of throw, viz, the height and the width of the picture upon the screen.

This table works "both ways" in that it tells the size of picture when the lens length and the screen distance are known in advance, or it will tell the lens length required to give a picture of a desired size when the screen distance and the picture size are known. The following examples show the use of the table:

(1) With a house in which the screen is to be forty feet from the projection machine, it is desired to project a lantern-slide picture *about* 9 feet square. In the table, the column is taken which has "40 ft." at its top, being the sixth of the narrow columns, counting from the left, and in this column the pairs of figures are examined until a suitable pair is found; in this column there is a pair of figures, 8.9 and 9.8, and at the left, in the first column of the table is the figure, 12. The meaning is that a 12-inch lens with the 40-ft. throw of the theater will give a picture (from a lantern slide with a $2\frac{3}{4}'' \times 3''$ opening in the mask, the usual song-slide size), which will measure upon the screen a little less than 9 feet in height and very nearly 10 feet in width.

(2) An operator is obliged to project lantern slides in a room where for convenience in placing his projector it must be 25 feet from the picture screen. He has three lenses for the lantern, 6-inch, 8-inch, and 10-inch. Which shall he use to get proper results at first trial, and not reveal a lack of skill and experience by making experiments before an audience? In the 25-foot column and opposite the figure 6 of the first column are found the figures, 11.2 and 12.3; in the same 25-ft. column and opposite the figure 8 in the first column are found the figures, 8.4 and 9.1; in the same 25-ft. column and opposite the figure 10 of the first column are found the figures, 6.6 and 7.3; the meaning is that the 6-inch lens will give a picture about 11 ft. × 12 ft.; the 8-inch lens will give a picture about 8 ft. × 9 ft.; and the 10-inch lens will give a picture about 6 ft. × 7 ft. The operator then measures or estimates the size of the screen and picks the lens which will give the largest picture that the screen will hold.

(3) To change the size of the picture, the table may be worked both ways at once, as it were, taking the results by an inspection of the table by differences, since the object is to make a difference in the size of the picture now being projected by making a difference in the length of the lens used. With a 45-ft. throw and a 9-inch lens, the picture is too large. Going into the table to find the size of picture, it is found to be 14.8 ft. wide, or about 14 ft. $9\frac{1}{2}$ in. Now taking the table to find the size of lens for a smaller picture, the $9\frac{1}{2}$-inch lens gives a picture 14 ft. wide; thus, by the table, a difference of half an inch in the length of the lens makes a difference of $9\frac{1}{2}$ inches in the width of the picture. By actual measurement on the screen, the projected picture with the old lens may be several inches different from the size given in the table, but the difference in the table for the difference in the lenses will hold good, and is the safest way to figure for a new lens.

To obtain the focal length of a lens accurately, put it in a photographic camera and focus upon any object, say a strip of paper three inches long pasted upon a window pane, until the image on the ground glass is exactly the size of the object itself. Then the focal length of the lens is one-quarter of the distance from the ground glass to the object itself.

Estimating Lens Length. In estimating the lens length to fill a given screen with a given throw, a margin should be left upon the screen all around the picture. Many lantern slide masks are not exactly centered with reference to the position of the opening of the mask and the edges of the glass plates. Many slides, and particularly announcement slides, will exceed the usual standard limit of $2\frac{3}{4} \times 3$ inches, running even to 3 inches in height and $3\frac{1}{2}$ inches in width. A single slide which runs over the edge of the screen in an evening's exhibition will discredit the theater. It does not create in the minds of the audience the proper thought that the slide maker has been in error, that the slide is abnormal and too large for the screen, but creates instead the thought that the screen is too small for the slide or that the operator's skill is too small for his job, and that the theater is a small caliber place in general.

Calculating Lens Data Without the Table. The rule used is the "rule of three" or the rule of simple proportion among four quantities; three being known, the fourth always may be found by simple arithmetic.

For practical purposes, the rule may be taken, *that the slide is to the picture as the focal length is to the throw.* That is, the proportion between the size of the mask window in the slide and the picture as projected upon the screen is the same as the proportion between the focal length of the projecting lens and the distance of throw, lens to screen.

To make this rule available for arithmetic, it is placed in the form

$$\text{Slide} : \text{Picture} :: \text{Focal length} : \text{Throw}$$

from which the equation is taken

$$\text{Focal length} \times \text{Picture size} = \text{Slide size} \times \text{Throw}$$

This equation works out for the height or width of the picture, according as the height or width of the slide is taken. Taking any three of these measurements as known, the remaining measurement may be obtained, as follows:

For Lens Length. Multiply together the slide size (say 3 inches wide) and the length of throw measured from the lens to the middle of the picture screen, taking both in *inches.* The result is to be divided by the width of picture which it is desired to project upon the screen, also taken in *inches,* and the final answer thus found will be the length of focus of the lens, in inches, which will be needed. All measurements must be reduced to inches before multiplying and dividing.

In calculating for the projection of lantern slides upon a screen used also for motion pictures, it must be remembered that the shape of the lantern-slide picture is different from that of the motion picture; if the screen takes the shape of the motion picture, the lantern-slide picture cannot be made to fill it, and should be calculated for height, not for width. With a motion picture 9 ft. × 12 ft., the lantern-slide picture will be 9 ft. × 10 ft. or 10 ft. × 11 ft. to secure the most pleasing effect in changing from one to the other quickly.

Example. *Calculating lens length.* For a 30-ft. throw, it is desired to project a picture 10 ft. wide. 30 ft. is 360 inches and 10 ft. is 120 inches. The slide is 3 inches wide. 3 × 360 (slide size multiplied by throw) gives 1080; then 1080 ÷ 120 (the first result divided by the picture size desired) gives as an answer, 9, meaning that a lens of 9-inch focal length will give the desired size of picture at that throw. The picture will be slightly smaller, because the distance from the slide to the lens is slightly greater always than the actual focal length of the lens. The lens table gives the size of picture with a 9-inch lens at 30 ft. as 9.8 ft., or 9 ft. 9½ in., or about 2½ in. smaller than the simple arithmetical calculation.

For Picture Size. Multiply together the slide size in inches and the length of throw in inches, then divide by the focal length of the lens in inches. The picture projected will be only a trifle smaller than the answer obtained.

Example. *Calculating size of picture with any lens.* With a throw of 35 ft. and a 10-in. lens, reduce the throw to inches, 420 inches, multiply by the width of the slide. 3 × 420 (slide size multiplied by throw in inches) gives 1260; then 1260 ÷ 10 (the first result divided by the length of the lens in inches) gives 12 ft. 6 in. Here the table gives 12.3 ft., or 12 ft. 3½ in.

For Slide Size. It might seem that the operator would not have this calculation to make, since as an operator he would not

HER OLD SWEETHEART APPEARS AT HER WEDDING

Scene from Photoplay, "True Love Never Dies"

SCENE FROM "THE LAST EDICT OF FRANCIS II," BY ECLIPSE
An Historical Drama Vividly Portraying the Character of Catherine de Medici
Courtesy of the *Kleine Optical Co., Chicago*

have to make slides. It is involved in the making of emergency slides where the operator wishes to cut the mask with the largest opening which can be projected upon his screen. It is involved in the selection of announcement slides, which have mask windows of different sizes, many of them too large for the operator's picture screen. By this calculation, the operator may determine the largest slide-mask window which his screen will take with the lens he is using, and can select announcement slides which fall within the limiting dimensions.

Multiply together the focal length of the lens and the size of the picture projected or which it is desired to project, in inches. Divide the result by the throw in inches. The final answer will be the dimension which in the slide window will fill the screen as desired when projected. If the width of picture has been taken in the calculation, the result will give the width of the slide-mask window. If height of the picture has been taken in the calculation, the result will give the height of the slide mask window.

EXAMPLE. *Calculating slide-mask window.* With a throw of 30 ft. and with a 10-in. lens, the screen is 8 ft. 9 in. by 10 ft. 6 in. By the table the 10-inch lens gives a picture 8 ft. by 8.8 ft., or 8 ft. by 8. ft. $9\frac{1}{2}$ in. It is desired to fill the screen within a few inches, to project a picture, say, 8 ft. 6 in. by 10 ft. 3 in.

For the width, 10×123 (the focal length of the lens in inches multiplied by the desired width of the picture in inches) gives 1230; $1230 \div 360$ (the first result divided by the throw in inches) gives $3\frac{5}{12}$ as the final answer. The slide-mask window may be about $3\frac{1}{2}$ inches wide.

For the height, 10×102 (the focal length of the lens in inches multiplied by the desired height of the picture in inches) gives 1020; $1020 \div 360$ (the first result divided by the throw in inches) gives $2\frac{5}{6}$ as the final answer. The slide mask may be about $2\frac{3}{4}$ by $3\frac{1}{2}$ inches to fill the screen.

For Length of Throw. This calculation is required when the operator, having but one lens available, must determine how far from the screen to place his projection machine to secure a picture of the desired size. Aside from private exhibitions, in parlors or improvised halls, it has little value.

Multiply the focal length of the lens by the desired picture size and divide by the slide size, taking all dimensions in inches. The answer will be the distance in inches from projection machine to screen, or length of throw.

EXAMPLE. *Calculation of length of throw.* The operator has but a 6-inch lens, and the screen provided is 5 × 6 ft. Taking 5 ft. 6 in. as the widest picture safe for the size of screen, 6 × 66 (focal length in inches multiplied by picture width in inches) gives 396; 396 ÷ 3 (first result divided by width of slide mask window in inches) gives 132 inches, or 11 feet as the length of throw.

If an 8-inch lens were available, the calculation would give 8 × 66 ÷ 3, equal to 14 ft. 8 in. as the length of throw. Such small dimensions as these, met only in private exhibitions, will not be found in any table, and when such dimensions are encountered the rule for calculation without the table becomes of use.

Accurate Calculations. The distance from the lens to the lantern slide always is a little greater than the focal length of the lens. This difference has been omitted from the foregoing rules because the variation is small in the final results and within the variations of probable error in taking the measurements in the first place.

For greater accuracy, the length of throw should be taken along the axis of the projection lens or of the optical system. Let T equal this length of throw, lens to screen, F equal equivalent focal length of the lens, S the slide-mask window dimension, and P the corresponding picture dimension, all dimensions being taken in inches or in the same unit.

By the law of optics which may be called the "Law of the Relation of Image Sizes,"

$$S : P :: D : T$$
$$ST = PD \qquad (1)$$

By the law of optics known as the "Law of Conjugate Foci,"

$$D-F : F :: F : T-F$$
$$F^2=(D-F)(T-F) \qquad (2)$$

These two equations include five variables, S, P, D, T, and F, of which the value of the variable D never is required in practice. Of the remaining four variables, S, P, T, and F, when any three of the four are taken as known or assumed or desired, the remaining one may be determined accurately by the operations of simple algebra.

As the final focus is obtained by *shifting the position of the lens,* and as the position of the lens depends upon its focal length, which focal length has not been determined as yet at the time of measuring for the dimensions for the calculation, the only distance which can be measured along the axis of the optical system is the distance from the slide to the screen. Let H equal the distance from the slide to the screen, then, by the premises of the problem,

$$D+T=H \qquad (3)$$

From the three equations (1), (2), and (3), any one of the four dimensions, S, P, H, and F, may be determined accurately, when the remaining three are known or assumed or desired.

Lens Construction and Adjustments. Projection lenses are made up of a number of glasses, at least two, front and back, the focal length of each glass being greater than the resulting focal length of the combination. If still another glass were added to the combination, the focal length would be reduced as a result of the addition. Lenses of small curvature in clip-cap holders, similar to that shown in Fig. 34, may be used to change the size of pictures slightly and at a very small cost. The size of a picture may be decreased by ten per cent in this way, and by the use of a "negative lens" similarly mounted in a cap, the size of the picture may be increased slightly.

Care of Lenses. Every day, wipe the outside surface of the lenses with a soft camel's hair brush, without taking the lenses from the tube or the tube from the holder. The hair of the brush should be an inch long, without any stiffness whatever. The type of brush known as "camel's hair pencil," consisting of a bunch of camel's hair drawn into a quill, is suitable, a large size of pencil (yet smaller than a lead pencil) being chosen. In wiping the surface of the lens, the brush should not be bent to rub the lens with the quill or handle, but to stroke the glass with the hair of the brush to sweep away dust grains or fine particles of lint which may have floated to the surface of the lens. Keep the brush in an envelope, such as is used for mailing letters, when not in use that it may not collect dust. The movement of the brush is to sweep away dust grains, not to polish the glass or clean it of finger marks. If the glass gets finger marks, more violent treat-

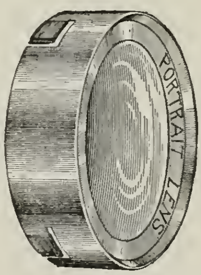


Fig. 34. Clip-Cap Lens, or Auxiliary Lens

ment, say with an extra soft chamois, is necessary to wipe them away; keep the chamois also in an envelope away from dust.

With time—and it is a matter of months rather than of days—lenses will acquire a gray film upon their inside surfaces. This may be removed by washing with alcohol and wiping with a dry, soft cotton rag, then polishing with soft chamois. The alcohol should be $\frac{1}{4}$ alcohol and $\frac{3}{4}$ water, as the pure alcohol will dry upon the surface of the lens so quickly that it will leave the surface as bad as before. In taking out the lenses, lay them carefully and in order upon the table where you are working, then take them up one only at a time, cleaning it carefully and putting it back in its proper position, so that there will be no possibility of a mix-up when they are put back in the tube. Once a year is often enough.

FOCUSING

The general subject of focusing is involved throughout the adjustment of the optical system of the lantern, and focusing the light has particularly to do with the adjustment of the lamp with reference

Fig. 35. Diagram of a Slide in Focus upon the Picture Screen

to the position of the arc relative to the condensers. The relation of the projected image to the screen upon which it is to be viewed now will be considered.

The final focus is attained by moving the stereo lens slightly forward or backward in its holder to bring the converging rays of light into focus upon the picture screen. From each point of the lantern slide a bundle of rays passes to the lens, striking all over the back surface of the lens, being bent within the lens and passing out of it practically from all over the surface of the front glass; then the bundle begins to draw together and finally converges into practically a single point, or very small spot of light. The distance of this spot from the lens is dependent upon the distance of the lens from the slide, and by proper adjustment of the position of the lens, the sharp focus of the bundle of rays may be made to occur upon the surface of the picture screen. This gives the condition illustrated in Fig. 35. The

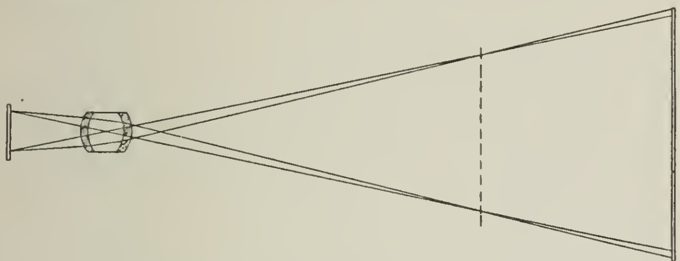


Fig. 36. Diagram of a Slide Out of Focus Upon the Picture Screen. Lens too far from Slide

lantern slide is at the left, the lens near it, and the picture screen is at the extreme right. The bundles of rays from the lens meet upon the screen surface.

For illustration of the out-of-focus conditions, Fig. 36 is given, illustrating the condition when the lens is too far from the lantern slide, and Fig. 37 is given, illustrating the condition when the lens is too close to the slide.

In Fig. 36, the converging bundles of rays leaving the lens cross before they get to the picture screen and spread again, reaching

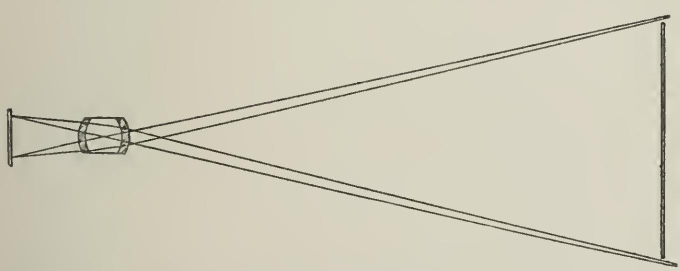


Fig. 37. Diagram of a Slide Out of Focus Upon the Picture Screen. Lens too close to Slide

the screen slightly spread out, the different adjacent bundles blending into each other and producing the blurred effect upon the screen well known as a slide out of focus. The true focus of the image is at the dotted line drawn across the rays at the point of crossing of each of the bundles of light. This would be the proper position of focus for the lens if the screen were nearer, and the image is correspondingly smaller, in proportion to the lesser distance of the screen from the lens. This diagram shows clearly how the nearer screen or shorter "length of throw" gives a smaller picture upon the screen for the same lens, or same focal length of lens, as shown by the lens table. The "focal plane" or "image plane" represented at the dotted line of Fig. 36 may be moved forward toward the picture screen at the right of the figure by moving the lens back toward the lantern slide.

In Fig. 37, the lens is shown moved too far toward the slide. The converging bundles of rays now do not meet before they reach the screen, nor even at the screen, so that the result is a blur in the projected image, as before; as a matter of fact the rays would meet far to the right of the diagram, producing a very large picture upon a more distant screen.

The best adjustment for focus is attained only by experimental adjustment, moving the lens forward until it is just a little too far, then moving it backward until it is just a little too near, then taking a position between. With a cheap lens, sharp focus may not be obtained all over the field of the picture screen at once, because of the feature of curvature of field, or curvature of the image surface.

Curvature of Image. The surface, or the imaginary surface, upon which the image is brought into focus has been called, as quoted, the "focal plane" or "image plane" because it ought to be a plane or flat surface. To make it so, or even approximately so, requires specially constructed lenses for projection, involving usually a greater number of glasses in the lens tube and a correspondingly greater amount of labor and skill in manufacture and correspondingly higher prices to the purchaser of the lens.

Curvature of the image is illustrated in diagram in Fig. 38; the slide is represented at *SL* with its surface flat, as it always is; the lens is shown at *O*, and the image is shown at *I* in a curved line. This diagram represents a sectional view through the center of the slide, lens, and image, taking a vertical section by cutting the whole theater, as it were, into halves. The shape of the image at *I* is spherical, or saucer-shaped, with the edges of the saucer bending toward the projecting operator and the center of the saucer bent back toward the middle of the picture screen.

If the lens be adjusted to bring the bottom of the saucer-shaped image to the surface of the screen, there will be had a very sharp focus in the middle of the screen, with gradual fading away of detail toward the edges of the screen, the corners being worst of all. By bringing the lens slightly nearer the slide, the middle of the image or bottom of the saucer of the image is, theoretically, pushed back through the screen, giving a slight blur in the exact middle of the picture, surrounded by a broad band or ring of sharply focused image, then fading slightly again toward the corners. This is the best condition of focus where the effect of curvature is manifested in the lens. The condition of adjustment with the center of the picture

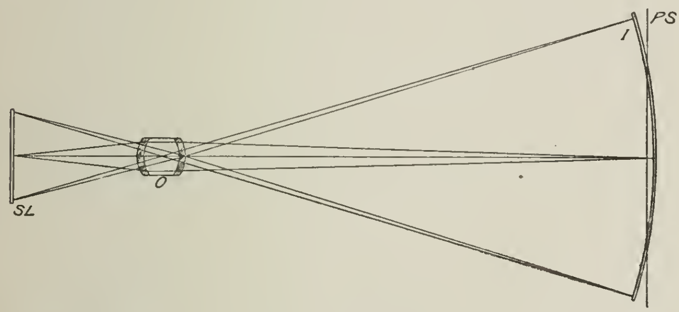


Fig. 38. Diagram Showing the Curved Image Surface of a Picture Projected by an Uncorrected Lens

slightly beyond the picture screen is illustrated also in Fig. 38, where the straight line *PS* represents the surface of the picture screen and the curved line *I* represents the curved line of the cut through the saucer-like image from the uncorrected lens *O*.

Remedy for Curvature. The only remedy for curvature of image is the purchase of a new and a better, more expensive lens. Such lenses are advertised as having a "flat field." The image surface of such a lens will be sufficiently nearly flat to improve the picture beyond the condition shown in Fig. 36, bringing both center and corners into focus at the same time when the picture screen *PS* is parallel to the slide *SL*.

Inclined Optical Axis. Very few theaters offer the advantage assumed in Fig. 38, that the center of the lens is opposite the center of the picture screen. Sometimes it is at the side of the center, sometimes it is far above the center, sometimes both.

In Fig. 39, the projection lens is illustrated as being placed at about the level of the top of the picture screen, a condition met in large theaters where the pictures are projected from the upper balcony, but not usual in small motion-picture theaters. The first

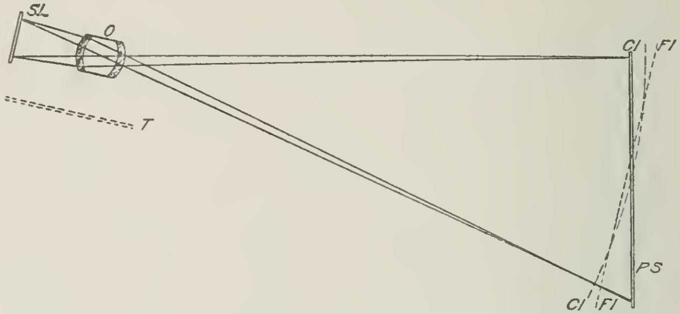


Fig. 39. Diagram of the Inclined Optical Axis

thought, when the ray of light from the lantern is thrown toward the screen and found to strike it near the ceiling, is to tip the whole projecting machine, table and lantern together, to make the center of the beam of light strike centrally on the screen. This is the condition taken in Fig. 39 for illustration of the inclined optical axis. Its results are shown in Figs. 39, 40, and 41.

At the extreme right of Fig. 39 is shown the vertical picture screen, and at the extreme left is shown the projection table top, slide, and lens. The table top is represented by the dotted parallel lines at T, showing its inclination. A little tilt can be endured, but the degree shown in the diagram would be fatal to good pictures.

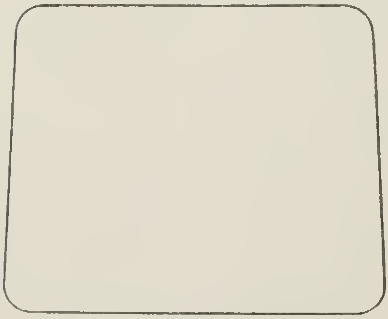


Fig. 40. Keystone Picture with Vertical Inclination

The slide SL in the slide carrier remains perpendicular to the table top T and, therefore, is tilted with reference to the picture screen PS. The lens O is parallel to the table top T and perpendicular to the surface of the slide SL; no advantage would be gained by having it otherwise.

The curved image surface is represented by the curved line

CI-CI extending in a curved line with its center opposite the lens *O*, but because of the inclination of the projection machine the curved image surface cuts the picture screen in but one place, instead of cutting it in two places as it did in Fig. 36. The defect of curvature of image surface, therefore, will be found to be made more objectionable when the operator is obliged to tilt his projecting table top. Nor will the substitution of a "flat-field" lens correct the trouble altogether. The image plane of a flat-field lens is approximately a flat surface at right angles to the axis of the lens. Such a surface is represented by the straight line *FI-FI* for the flat image in Fig. 39, but this flat image also cuts the surface of the picture screen *PS* in but one place and, therefore, will give but a band of sharp focus across the picture, the focus fading into blur slowly in either direction, upward or downward in the picture.

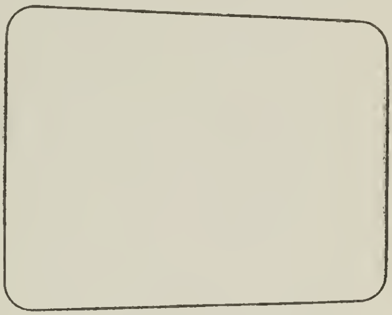


Fig. 41. Keystone Picture with Horizontal Inclination

The Keystone Picture. Further difficulties are found in the shape of the projected picture upon the screen. If the projection station is above the center of the screen, and the table top and the lantern are tilted downwardly, as shown in Fig. 39, the bottom of the picture screen will be farther from the lens than the top of the screen. As will be noted from Figs. 35, 36, and 37, the farther the distance from the lens to the screen, the larger will be the picture upon the screen; hence, as the bottom of the screen in Fig. 39 is farther from the lens than the top of the screen, the picture thrown upon the screen will be *larger at the bottom than at the t p.* This effect is shown in Fig. 40. The top and bottom edges of this figure are parallel but the sides are not. It is the shape of the "keystone" picture, the picture which results when the optical axis of the projecting machine is inclined, being tipped downward.

When the projection machine is placed at the side of the room, thereby bringing it down sometimes to the level of the middle of the screen, the picture becomes distorted in its top and bottom lines, appearing as shown in Fig. 41, a shape more objectionable than that of Fig. 40.

Remedy for the Keystone Picture. In the correction of faults such as this, the good operator proves his superiority over the poorer one. The keystone effect may be entirely corrected for small angles by setting the lantern slide eccentric to the lens (it is more accurate to state that the lens is set eccentrically to the lantern slide) and may be corrected for still greater angles by the eccentric slide in conjunction with a good flat-field lens.

The setting of the eccentric slide is shown in diagram in Fig. 42. In this figure, the lens *O* is above the level of the center of the picture screen *PS*, about half-way between the middle line and the top line. The table top *T* is brought back to the horizontal position, the slide

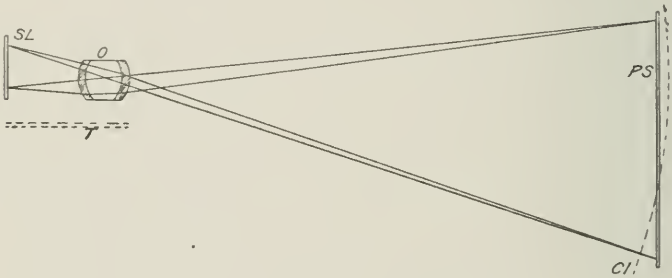


Fig. 42. Diagram of the Eccentric Slide

SL is vertical to the table top and is parallel to the picture screen, both the picture screen and the slide being vertical. The lens *O* is horizontal, parallel to the table top and at right angles to the slide and the screen, but it is dropped below the level of the center of the slide *SL*, so that a straight line from the upper edge of the mask window in the slide will pass through the center of the lens to the bottom of the picture in its desired position on the screen. The slide *SL* thus is not in the center of the lens (is "eccentric" to the lens) and the projected image is accordingly displaced, the slide being slightly above the lens in the lantern and the image being much below the lens on the screen.

With reference to keystone distortion: The bottom of the picture is farther from the lens, as it was in Fig. 39, but the top of the lantern slide also is farther from the lens than the bottom of the slide. The foot of the slide is farther from the lens center compared with the head of the slide in just the same proportion that the foot of the picture screen is farther from the lens center compared with the head of the picture screen. As the size of the projected picture is wholly a matter of proportional distances, the size of the picture may be worked out by arithmetic to prove that the shape of the picture is correct, or more simply it may be tried on the picture screen with the lantern. With reference to focus: The curved image of the lens is represented in Fig. 42 by the curved line *CI*, and it crosses the picture screen *PS* in only one place, just as it did in Fig. 39. While the focus of the cheap lens with the curved image has not been improved, neither has it been made worse. With the flat-field lens, however, the flat-image surface will be straightened up when the projection table and slide and lens are made level, so that the flat image now will be parallel to the picture screen, and the entire picture will be in focus, top and bottom, center and corners.

Lens Angle. With reference to the direction of the rays of light passing through the lens in Fig. 42, it may be noticed that from the foot of the inverted slide, the upper edge of the slide in the diagram, the rays of light enter the lens *O* at a greater angle than they enter the lens of Fig. 39. Some lenses will accommodate a wider angle of light rays than others. The "wide-angle" lenses are either larger in the barrel diameter or shorter in barrel length, as compared with a cheaper lens of the same focal length which is able to care for only the narrower angles of light. The length of focus can not be determined by looking at a lens other than by testing its ability to bring light rays to a focus, but, knowing its length of focus, the angle which it will cover may be judged by its shape, the shorter length of barrel almost invariably giving the wider angle and giving greater power to cover the lower corners of the picture on the screen when the slide is set off the center of the lens. In photographic lenses, a lens of 6-inch focal length usually is used to cover a 4×5-inch plate, but a 6-inch lens may be made which will give an image all over an 8×10-inch plate, four times the area. The same difference can be found in projection lenses. If the lower corners of the picture on the screen show dark, you require a new lens of shorter barrel and of the same focal length, or you will have to tip the table a little and endure the keystone effect or correct it by a slide-holder keystone mask.

Two diagrams comparing the work of a narrow-angle lens and a wide-angle lens are shown in Figs. 43 and 44. At the left of each diagram is shown the lantern slide to be projected. It is seen that the lens of Fig. 43 has sufficient angle to project the slide if the slide is placed centrally within the solid lines representing the limits of the rays of light, but that if the slide is placed eccentrically above the center of the lens, as shown, the rays of light must pass as indicated in dotted lines, and the lens will be unable to do the work. In Fig. 44, however, the slide as placed eccentrically still falls within the working angle of the lens and the wide-angle feature of the lens thus permits that placing of the slide with satisfactory projection.

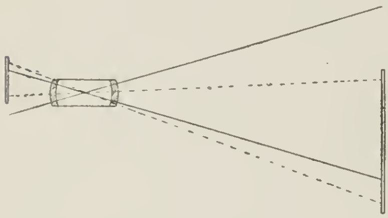


Fig. 43. Diagram of the Eccentric Slide with a Narrow-Angle Lens

Do not believe a salesman who tells you that "a lens is a lens and that is all there is to it." Get another salesman. There are differences in lenses. The working angle of the lens and the flatness of field or image are the two points in which all the cheaper lenses and some of the higher priced lenses will be found lacking. When the conditions of the theater force you to set the lens off the center of the slide, both flatness and wider angle will be needed for a good projection. Otherwise, the wider angle is a needless expense.

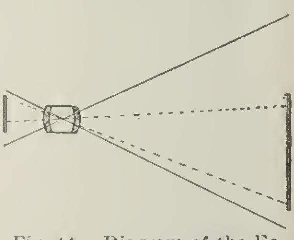


Fig. 44. Diagram of the Eccentric Slide with a Wide-Angle Lens

Inclined Screen. To reduce distortion in the picture with a lens of narrow angle, the screen may be inclined slightly, as shown in Fig. 45. This brings the optical system back to the fundamental condition of Fig. 1 and of Fig. 35. The inclined screen is objectionable to the spectator because of the difference in distance from the eye to the top and to the bottom of the screen, and this difference will itself bring in the keystone effect to the spectator's vision, even though the picture upon the screen be perfectly rectilinear.

All of the remedies for distortion may be used at once, inclining the screen a little, tipping the table a little, and setting the lens off center a little, including also the keystone mask.

The Keystone Mask. The keystone effect of Fig. 40 may be compensated for, so far as the edges of the picture are concerned, by providing the slide holder with a keystone mask for the window through which the slide is projected, the edges of the mask being a little smaller than the mask of the slide. Measure the angle of inclination of the sides of the picture on the screen and make the sides of the mask have the same angle of inclination. The top and the bottom lines of the mask are parallel if the picture on the screen is true in that detail. The mask now is placed in the slide-carrier window with the narrow edge up; the lens magnifies the upper edge of the mask because of the greater distance to the picture screen,

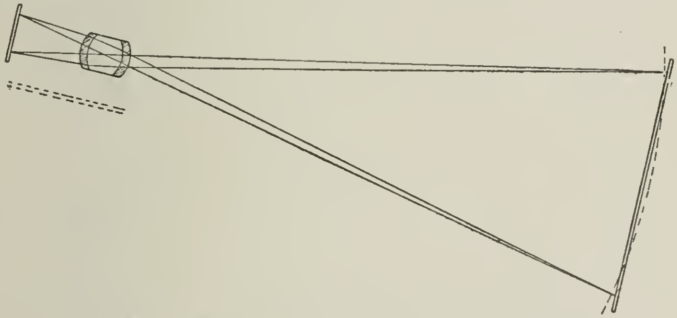


Fig. 45. Diagram Showing the Inclined Picture Screen

and the keystone mask throws a rectilinear field of light upon the screen. Two masks will be needed, one for each end of the slide carrier, or one for each lantern of a dissolver. A single mask for the fixed window of the slide holder would be too far out of focus to give good service. The keystone mask will not correct the distortion of the image itself, but only correct the margins of the projected picture. With lantern slides of varying sizes, only those larger than the keystone mask will be corrected, and those of course are corrected by the cutting off of a portion of the edge of the picture as seen in the mask window of the slide itself. With the motion head, where all images for projection are of uniform size, the keystone mask becomes more practical. Greater skill is required in fitting it, because of its smaller size.

LANTERN SLIDES

Announcement Slides. Commercial announcement slides very frequently are over-sized. In selecting them, care should be taken to avoid getting a slide which will project a picture or field larger than the screen.

Emergency Slides. The quickest emergency slide is made of two cover glasses, a slip of draftsman's tracing paper or tracing linen, India ink, and a binding strip or piece of gummed paper. The mucilage edge of an envelope flap is always available for gummed paper when nothing else can be had. A lantern-slide mask or window is desirable, but not necessary. Write with a fine pen upon the tracing paper or linen, place between the glasses, stick together with the gummed paper and put it into the lantern. If cover glasses are not at hand, the binding strip may be slit on a couple of song or announcement slides and the cover glasses thus obtained. This slide is improved by turning the tracing paper over and tracing the writing on both sides of the sheet before putting it into the cover glasses.

Cover glasses, masks, and binding strips should be at hand at all times for the repair of slides. Add to this equipment a bottle of Higgins Waterproof Ink and a supply of crowquill pens and tracing paper and the emergency slide-making set is complete. Cut the tracing paper to lantern-slide size, place a mask upon each small sheet, and run a sharp pencil around the window of the mask. When writing, keep the words inside the pencil line and parallel to the edge of the sheet.

For a typewritten slide with this outfit, cut a larger sheet of tracing paper, place a mask upon it, and run a sharp pencil around inside and outside of the mask. Place this sheet in the typewriter with a carbon sheet back of it, the carbon surface against the back of the tracing paper. Write within the inner window line. When taken from the machine, the sheet will have the ink of the ribbon on one side and the carbon of the transfer paper on the back, giving a double density for projection. If the written matter is not centered in the window, the mask may be adjusted over it, the pencil run around the outside of the mask, and the sheet trimmed to the new margin; then bind between cover glasses with gummed paper.

Unless skillful in making the Roman letters, the script form of writing will produce the more acceptable result, since mistakes in spelling and in form of letters are less likely to occur.

Repair of Slides. The cracking of the glass of a lantern slide usually occurs in the cover glass, not in the photographic plate. Slit the binding strip around the edge, throw away the cover glass and substitute another which has been cleaned with alcohol and polished with a chamois or piece of newspaper; rebind with a new strip of gummed paper. If the photographic plate is broken, it is better not to attempt repair upon a rented slide. If you own the slide, it may be repaired as follows: *Place the broken parts glass down upon a cover glass and cement them to it and to each other with Canada balsam thinned with a little turpentine, leaving them until well set. Then cover and bind; if too thick for the slide carrier, project without cover glass.*

TWO SCENES FROM PHOTOPLAY, "HER MASTER"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

SCENE FROM PHOTOPLAY, "THE FAIR DENTIST"
Courtesy of *Independent Moving Pictures Co., New York*

BESSIE DISCOVERS THE ATTEMPT TO LYNCH HER SWEETHEART

Scene from Photoplay, "Bessie's Ride"

Courtesy of *G. Melies Company, New York*

MOTION HEAD

PART I

PORTRAYAL OF MOTION

Abstractly considered, apart from the means for projecting it and from the means for recording it, the motion picture is a picture in which motion is the prime feature. It is a picture so recorded that, itself a record of a moving thing or set of things, it, when properly viewed, will reproduce to the viewing person not only the outlines and details of the objects pictured but also the motion of the objects pictured.

A running horse portrayed by a fixed picture, such as a lantern slide or fixed print, will show the outlines of the horse in full detail in the properly lighted portions of the animal and of the background; it even will suggest motion, by reason of the position in which the animal is portrayed, perhaps with two feet off the ground or even galloping with all four feet clear of the earth; but in such a picture the motion is only suggested by the attitude portrayed by the still picture. The motion picture must do more than merely suggest the motion of the subject photographed; it actually must show the motion so that there is no doubt in the spectator's mind that the object being exhibited is in motion, or was in motion at the time it was photographed. Yet the motion picture in itself is a dead, inert photograph. How, then, is motion portrayed in it?

Go back to the thought of motion in the subject itself. In what way is motion manifested to the spectator viewing the subject? The movement of the subject is known only by observing it twice and noticing whether it is or is not in the same place or position both times. If it is in the same place both times it is observed, then we say that the subject is still. If it is, upon a second look, in a position or location different from that of the first look, the observer says that the subject has moved. Now looking a third and fourth time, and noting that each time the subject is in a different position from any of the other positions which it has held, the observer says that the subject is moving continuously, and if the differences are all the same, and if we have looked at regular intervals, the observer concludes that the subject is moving at a uniform rate.

Looking at a thing several times to see whether it is moving is an act performed unconsciously. The eye cannot look at anything for less than one-fiftieth of a second, because of a peculiar property of the eye called "persistence of vision," and when anything is seen in any position, it is seen for that length of time. If it is not looked at longer than that, the impression of motion is not given. Looking at it for half a second, it is seen successively in twenty-five different positions, or the equivalent, and when the observer looks at an object for half a second to see whether it is moving, and finds that it is moving, he really has looked several short looks joined each after another, and in each of the brief looks the object has been in a different position from that of the preceding look; proof of motion thus has been received.

Proof of Motion. Proof of motion is conclusive to the human mind when upon looking continuously at a physical object in nature it is observed to change its position. Proof of motion in the subject of a picture may be offered by the same means of making it apparent to the eye; that is, while the eye is looking continuously at the subject portrayed in the picture the subject is observed to change its position in the picture.

A series of pictures may be made with a single camera, which, by close notice, will prove motion. Assume that an amateur photographer with a hand camera is taking pictures as rapidly as his skilled hands will enable him, the subject being a parade passing down a city street. The camera worker is situated on one side of the street opposite a prominent building, of which the two corners and the central door may be seen in each picture made of the procession. When these pictures are developed and printed, it is noted that in one picture a carriage drawn by distinctive white horses is seen at the right of the picture, apparently entering the picture, judging from the attitude of the horses and the direction of their heads. This suggests motion, but does not prove it. Another picture, however, shows the horses half-way between the corner of the building and the central door; another picture shows the horses opposite the door of the building, with the carriage still close behind; still another picture shows the horses near the left of the picture, with the carriage close behind and the heads of the horses still toward the left. By comparing these pictures, the thoughtful observer will conclude, and correctly, that the horses and the carriage were moving while the series of pictures was being taken. These pictures, when taken together as a series, are pictures of motion and show motion if one studies to see it. The modern perfected motion picture is but the elaboration of this method of recording motion, and the projected motion picture is but a perfected method of viewing it.

Fig. 1. Motion-Picture of Harvesting Machine in Operation

Perfected Motion Picture. The perfected motion picture makes a series of pictures similar to the series of the procession, but makes them so rapidly one after another, with such a short space of time between pictures, that the change or difference between pictures is very small, the motion being shown by increments from picture to picture. Take for example the motion picture of Fig. 1, which shows a harvesting machine or reaper cutting grain in the field. One part of such a machine is a large revolving flail, comprising a wheel-like formation of six or eight slats revolving over the sickle or cutting bar to prevent the cut stalks of grain from falling forward and to control their fall backward over the sickle bar. This wheel of slats revolves rapidly as the reaper is driven across the field, cutting the grain. Note the picture for the motion of the slats. In the top picture, the slat next the top reaches to the driver's hat and is exactly in line with the brim of the hat. In the picture next to the top figure, taken only one-fourteenth of a second later in time, the slat is not seen at the brim of the driver's hat but noticeably above the brim, and much nearer the top slat, for the top slat is descending. In the third picture, the slat being watched is as high as the top of the driver's hat and is higher than the slat, formerly the top slat and now going down. In the fourth picture of the series the slat being watched is slightly above the height of the driver's hat. In the fifth picture, taken about a quarter of a second after the first picture, the

Fig. 2. Motion-Picture Portrait of a Lady

slat being watched has reached nearly its full elevation at the top of the wheel, and the next slat has reached the height of the driver's shoulder. In the sixth and last picture of the series, the slat has moved from the driver's shoulder to the height of his chin. Also note the position of the driver. In the first picture, not all of his body is in the picture; in the second, it is all in the picture; in the third, there is a space between his body and the margin of the picture; in the fourth, the space is wider; and in the fifth and sixth, the space between driver and edge of picture continues to widen.

In Fig. 2, a motion picture is shown of circular form instead of strip film form. In this figure, it may be determined by studying the small pictures in sequence that the lady begins and ends the picture with a profile view, but turns her full face toward the camera during the progress of the picture, also she raises her hands to her head as though arranging her hair.

In both Fig. 1 and Fig. 2, the difference between any two consecutive pictures is so small that the pictures are alike except upon the closest inspection.

In taking pictures of objects which are in motion at such speeds as the eye can follow easily, and where the desire is to reproduce the motion pretty much as it was seen by the eye when viewing the physical object, an interval of about one-fourteenth of a second is taken, the object being photographed at the end of each one-fourteenth second, as is the case with the harvesting machine. In the case of motions which are so slow that the eye with ordinary observation cannot notice the motion, a longer interval of time is conveniently taken. A growing plant may be photographed once each day, and not oftener than once each hour unless it is desired to portray the opening of a single blossom; with these pictures taken at these comparatively long intervals, the change between successive pictures will be very small. In the case of motions which are so fast that the eye cannot follow the motion, a much shorter interval of time must be taken, in order that the change in the position of the moving object in successive pictures will be very small. The wings of an insect in flight move so rapidly that to the eye they are but a blur, and to

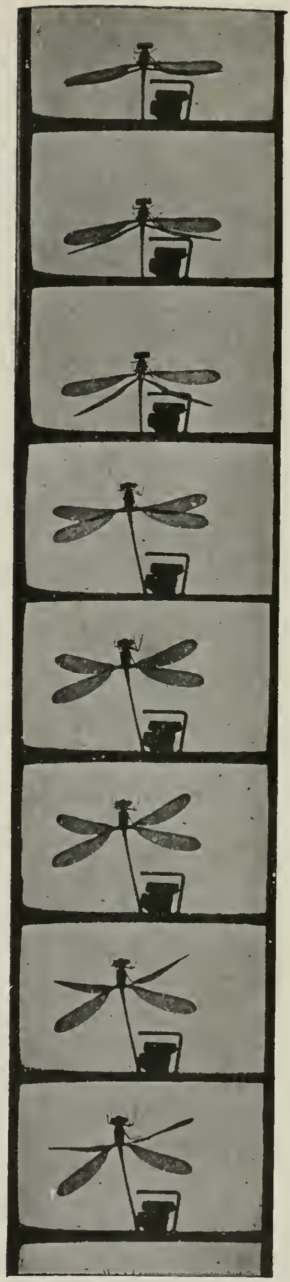


Fig. 3. Motion Picture of an Insect, Made at High Speed

photograph them in a manner that will reveal their proper motions for study requires that they be photographed at much shorter intervals than one-fourteenth of a second. Pictures of this class have been taken at the rate of two thousand pictures in one second. Fig. 3 shows such a picture, the subject being a dragon-fly in full flight. Motion pictures of bullets in flight have been taken at the rate of five thousand pictures in a single second.

This is the motion picture—a picture which shows a record of the successive positions taken by a moving object in successive intervals of time. Whether the picture takes the form of pictures in a row upon a transparent celluloid strip, as the original of Fig. 1, or whether it takes the form of a spiral line on a souvenir postcard, or whether the successive pictures were taken at the rate of fourteen per second, fourteen per year, or fourteen in one-hundredth of a second, all is immaterial, since in any of the cases the fundamental requirement is fulfilled and it is a picture of motion.

Viewing Devices. The perfected projecting machine is but one form of viewing device. Just hold a slip of white paper above the film gate and watch the picture film as it enters the gate; the full motion of the drama takes place there. The intermittent mechanism presents picture after picture at regular and proper speed, and the motion of the picture is seen without projection.

With the card of Fig. 2, the method of viewing is entirely different. The card is placed upon a light carrier, similar to the disk of a talking machine using the flat type of record; an eyepiece is conveniently placed, and as the disk of the picture revolves with a step-by-step movement, the eyepiece moves across as the reproducer needle of the talking machine does. Thus the pictures are seen in order. By taking a transparent print from the negative, projection upon a small scale may be accomplished.

With the picture strip of Fig. 1, it is necessary only to see the pictures successively, and preferably for ordinary scenes to view them in succession at the same speed that they were taken by the camera. To do this, some device is required to take away the first picture and substitute the second picture, then to take away the second picture and substitute the third, and so on indefinitely, that all of the pictures of the series may be viewed by looking at the same viewing position, as by looking at a screen upon which the pictures are projected in rapid succession. Further, to attain the illusion of motion in the picture, the spectator should be deceived, if possible, into believing that he is looking at the same picture all of the time, at least in so far as the fixed objects of the picture are concerned. This illusion can be obtained by making the shift from one picture to another imperceptible to the spectator, which is done by making the time of shift as brief as possible, bringing it at least reasonably near to the limits of persistence of vision.

Persistence of Vision. The human eye does not see an object instantaneously. Time is required for the muscles and nerves to act. What length of time is required by the eye and brain to appreciate a view after the light has fallen upon the lens of the eye has not been recited, nor has it been told what length of time is required for the eye to cease seeing the vision after the light has ceased to fall upon the lens, for the eye is slow about quitting as well as beginning; but it has been established that the eye seems to see any view probably one-fiftieth of a second longer than light actually falls upon the lens of the eye This action of the human eye is called by the name, "persistence of vision," because vision seems to remain or persist in action after the thing viewed actually has vanished.

One effect of the persistence of vision is that, when two views are seen with an interval of not more than one-fiftieth second between the two, the eye blends the two and, therefore, does not appreciate the interval of darkness which has occurred between the two. If the pictures are entirely unlike, there is a blur of confusion of the two. If the pictures are alike in some details and different in other details, then it seems to the eye that the similar details have not changed and that the unlike details have changed.

In the dissolving lantern, with two views showing a different use of figures before the same background or scene setting, skilfully dissolved, it seems to the spectator that the background details have not changed, that the same picture has been viewed continuously, but that the figures of the picture alone have changed their pose.

In the series of photographs of the procession studied as an example, it was by the comparison of a moving object with a fixed object in the picture that motion in the fixed object was proven. In the same manner, it is by comparison of moving and fixed objects in the projected motion picture that motion of the actors is made so realistic and so natural in its execution that it seems a reproduction of true life and the spectator is brought to realize that he is watching a picture of motion rather than a picture of inanimate things, or a picture in which motion is merely suggested as an art or trick or device. To secure this illusion, the fixed objects of the picture must remain absolutely motionless upon the picture screen.

With the perfected motion pictures and motion-projecting machine, exactly the illusion of the dissolving lantern is desired. Two successive pictures must be projected with such skill that the spectator is deceived into believing that he is looking at a single picture of a scenic setting or fixed objects of the picture, and that, watching a single picture, the moving objects have changed their positions.

Many projecting devices embodying the principle of the dissolving lantern—namely, the principle of projecting the second picture before the first picture is taken away and then of projecting the third picture before the second picture is taken away, and so on through the series—have been suggested and some of them have been operated successfully. However, the projecting device which has come into general use depends upon the phenomenon of the persistence of vision to smooth over the change from picture to picture, the change being made so quickly and so smoothly that the human eye cannot detect the coming of the new picture or the going of the old, nor guess at the interval of darkness or of blur which occurs between the two.

Projection by Persistence of Vision. The method of projection which takes advantage of the persistence of vision fills the requirements of the case entirely and is entirely satisfactory when well done. Its theory is that the first picture may be shown upon the screen, that the first picture may be cut off from the screen by a shutter, that the film may be shifted to bring the second picture in position for projection, and that the shutter may be removed to permit the projection of the second picture, all in a space of darkness upon the screen so brief that the first picture projected will persist in the vision of the spectator until the change in the motion head has been made and the second picture is upon the screen, when the spectator will see the fixed objects of the view in their places in the second picture as in the first, with the moving objects of the view changed to their next position, whereby the spectator believes that he has had continuous vision and believes that the fixed objects have been upon the screen in fixed position all the time, and that the moving objects also have been upon the screen all of the time but that they have moved upon the screen to the new position. In the same manner, the second picture persists in the vision of the spectators until the dark interval is over and the shift has been made and the third picture is projected; the third picture persists until the fourth picture is projected, and so indefinitely until the picture is out, retaining all fixed objects in continuous and stationary vision before the spectator by the phenomenon of persistence of vision and showing the motion of all moving objects in the successive pictures, the pictures showing so small an amount of movement between successive pictures that the motion seems smooth and continuous and not jerky step-by-step projection which it really is. That jerkiness, by the art of the film maker and assisted by the art of the projection operator, must be smoothed out.

Motion Mechanism. The slowest speed at which it has been found practicable to project a series of images having ordinary motion, as of actors walking, and to smooth out the jerkiness which would be expected by the step-by-step nature of the projection when the persistence-of-vision method is used, is about fourteen pictures per second. Fourteen pictures are to be projected each second, and with uniformity. To expect the operator to make fourteen shifts, or fourteen voluntary motions resulting in shifts, each second, as in changing lantern slides, and to do it with regularity, is quite an impossible requirement, so a machine has been devised for doing the shifting in an automatic manner, at regular intervals, the length of the intervals depending only upon the speed at which the machine is driven.

When driven by an electric motor—a great convenience in some ways but a very great disadvantage in other ways—the entire operation is quite automatic, it being necessary only for the operator to adjust and start the machine and the projection of motion for some twenty minutes follows, presumably in an entirely satisfactory manner if the preliminary adjustments have been perfect. When not driven by a motor, the operator is provided with a crank, which is turned at a constant speed, and which results in the automatic shifting being performed under the driving power of the crank handle.

The automatic shifting device is called a *motion head,* and it replaces in functions only the slide holder of the lantern, all the other portions of the fixed optical lantern being retained. All the features of the optical lantern for song slides are retained in use with the motion head except the projecting or objective lens, a special lens for the motion pictures being carried upon the motion head itself.

OPTICAL SYSTEM FOR MOTION PICTURES

The optical system of the motion-picture lantern adds to the system of the stereopticon, two shutters, an intermittent shutter and a fire shutter. Because of the short-focus lens required for the greater magnification of the motion-picture image as compared with the fixed lantern slide, the motion-picture image or film strip of images is placed farther away from the condensers than is the fixed slide. With these two modifications, the two optical systems cease their differences, and the fundamental principles of one are the fundamental principles of the other. The arrangement of elements for the motion-picture system is shown in its usual form in Fig. 4, the picture screen or viewing screen, which would be located properly far to the right, being omitted from the picture in order that all the other elements might be drawn to a larger scale, more clearly and distinctly.

Lamp. As has been described under the discussion of the optical lantern for fixed slides, the motion-picture arc lamp is of maximum strength, giving a very strong light and a very intense heat, such as is suitable for the motion picture alone, and unsuitable for the lantern slide.

Condensers. The condensers are the same as used for the optical lantern for fixed slides, and are the same condensers, being carried by the lamp house from the motion head to the stereo lens, and again from the stereo lens to the motion head, but where the requirements for condensers for the motion head differ in any way from the requirements for the fixed lantern slides, the motion head should be given preference. Proper instructions for the adjustment of the condensers for the motion head are repeated here, as though they were to be used for the motion-head work alone.

Back Condenser. This is the condenser at the left in the diagram, next to lamp *L.* It is shown in the diagram as the thicker of the two condenser glasses, and usually is so in practice. The focal length may be as short as $4\frac{1}{2}$ inches. Its length of focus governs the distance of the lamp *L* from the back surface of the glass, and its length of focus in turn is controlled to some extent by the size of the lamp house, since the back condenser must take the rays of the lamp from a lamp position within the limiting range of movement permitted by the lamp house. Most lamp houses will permit the use of back condensers 4 to 8 inches focal length.

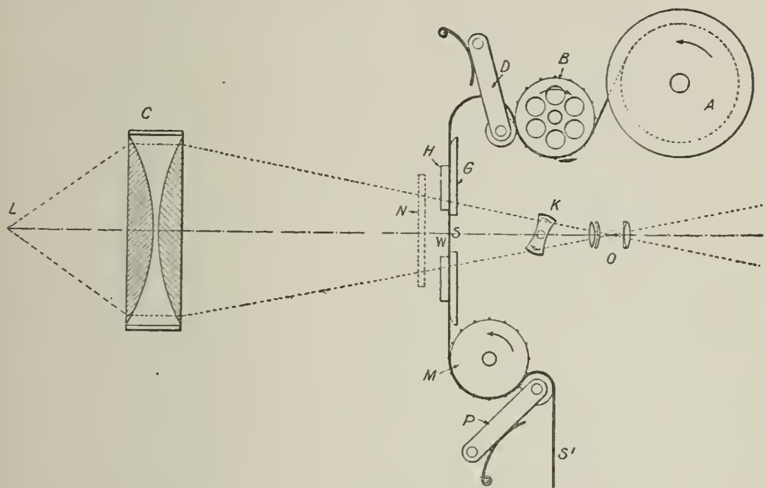


Fig. 4. Optical System for Motion-Picture Projection

A—Feed Reel; *B*—Upper Steady Sprocket, or Top Feed; *C*—Condenser Case and Condenser Glasses; *D*—Presser Roller and Arm for Top Feed; *G*—Film Gate; *H*—Tension Plate for Film Gate; *K*—Intermittent Shutter, Barrel Type; *L*—Lamp, or Point of Location of Arc; *M*—Intermittent Sprocket; *N*—Fire Shutter or Safety Shutter; *O*—Objective Lens or Projection Lens; *P*—Presser Roller and Arm for Intermittent Sprocket; *S*—Film in Film Window or Aperture of Film Gate; *S'*—Film leaving Intermittent Sprocket to Basket. The dotted lines represent the outer rays of the beam of light, and pass to the right to the Picture Screen, which is not shown in the figure.

The shorter the length of focus of the back condenser, the thicker will be the glass in the middle and the closer must be the lamp *L*, consequently the greater the heat upon the surface of the glass; incidentally, also, the brighter the light upon the picture screen. On the contrary, with a condenser of longer focus, the glass will be thinner in the middle, and will be farther away from the lamp, thus lessening the danger of breaking the glass. Incidentally, also, the less light will fall upon the condenser and, therefore, the less light will there be upon the picture screen.

The length of focus of the back condenser may be considered a compromise between the strength of the light on the screen and the risk of condenser breakage. Any length of focus within wide limits—4 to 8 inches, or in a large lamp house even much more than this—will give a properly distributed lighting of the screen, varying in brightness according to the length of focus used.

The shorter length of focus for the back condenser will require greater skill on the part of the operator in keeping the light in focus. The light being nearer, a slight change, say, an eighth of an inch, in the position of the arc, will make more difference upon the picture screen than the same amount of change would make with a condenser of longer focus. The longer focus of condenser (thinner glass) makes the lamp much easier to adjust for a smooth, evenly-lighted picture screen (provided *always* that your front condenser is of proper focal length) unless the back condenser happens to be so long in focal length that the lamp cannot be brought far enough back in the lamp house for it; such a condenser is too long for the lamp house, and good projection cannot be had with it. Of course, some sort of quality of picture can be thrown upon the screen with it, but it makes poor projection.

Front Condenser. This is the condenser at the right in the diagram, the outside one of the lamp house. It is shown in the diagram as the thinner of the two condenser glasses. The focal length should be exactly right to cause the rays of the lamp to come to a focus at the focal center of the objective lens *O*, whose position is determined by adjusting it properly in focal length and position in the motion-head lens mount in order to focus the picture film *S* properly and in proper size upon the distant picture screen.

Condensers are offered by all supply houses in lengths which vary by 1 inch, usually being offered in $4\frac{1}{2}$, $5\frac{1}{2}$, $6\frac{1}{2}$, and $7\frac{1}{2}$ inches. They may be obtained from the makers in focal lengths of 4, $4\frac{1}{2}$, 5, $5\frac{1}{2}$, 6, $6\frac{1}{2}$, 7, $7\frac{1}{2}$, 8, $8\frac{1}{2}$, 9, $9\frac{1}{2}$, 10, $10\frac{1}{2}$, 11, and 12 inches. In addition, they may be made to order of any length called for.

With a 9 by 12 foot picture at a 50-foot throw, an objective lens at *O* having a focal length of about 4 inches would be required. In connection with this there would be required for the lantern slides a stereo lens having a focal length of about 12 inches. With a difference of 8 inches between the two lenses, the distance from the lantern slide in its carrier to the motion-picture film in its gate should be about 8 inches, equal to the difference between the lens lengths

Taking the motion head as it stands on the table, the length of the front condenser is calculated in either case by simple addition. The focal length of the motion-picture lens is added to the distance from the film in its gate to the middle of the condenser box. In the instance taken, of a 4-inch lens, with 8 inches from the film to the slide position and another 2 inches back to the middle of the condenser box, it gives a total length of 14 inches for the focal length of the front condenser. This is the limit. A condenser longer than 14 inches will not give as good projection as one shorter; the front condenser should be 14 inches focal length or shorter.

Condensers as a Pair. The condenser glasses should not be of too great difference in focal length, as the lamp adjustments again become difficult, and are easier with the condensers more nearly of equal lengths. For the maximum illumination in the instance considered, a 50-foot throw and a 4-inch lens, with 14 inches from center of condensers to center of lens, the theoretical focal lengths required would be a 5-inch glass for the back and a 14-inch glass for the front. This combination gives an equivalent focal length of about $4\frac{1}{8}$ inches for the pair of glasses. About the same equivalent length for the pair of glasses would be obtained by the combination of a $5\frac{1}{2}$-inch glass and a $10\frac{1}{2}$-inch glass, by the combination of a 6-inch glass and a 9-inch glass; by the combination of a $6\frac{1}{2}$-inch glass and an 8-inch glass; or by the combination of two 7-inch glasses. Of these combinations, the 5 and 14 combination would be the hardest to work in practice but would be productive of the best results when properly worked by the skilled operator. The 7 and 7 combination will not give good results with any amount of skill on the part of the operator. The best combinations to use are the 6 and 9 or the $5\frac{1}{2}$ and $10\frac{1}{2}$; the latter is better if the glasses can be obtained, and its use lies well within any careful operator's skill.

Another consideration is the limits of the cone of light as determined in dimensions by the position of the optical center of the motion-picture objective lens and the sides of the film-gate window. This must not be larger at the condenser than the face of the condenser glass. In the instance assumed, the diagonal of the $\frac{3}{4}$ by 1-inch film-gate window is just $1\frac{1}{4}$ inches, and its distance from the optical center of the lens is about 4 inches (4.007″), while the distance from the optical center of the lens to the condenser face is about 13 inches.

By the proportion, $4 : 1\frac{1}{4} :: 13 : A$, where A is the diagonal of the cone upon the condenser face, a value of 4 inches for the dimension A is obtained, which is easily cared for by the usual condenser of $4\frac{1}{2}$ inches diameter of face when the condensers are of proper focal length and the lamp is properly adjusted.

When the cone, formed by the limits of the optical center of the lens and the corners of the film aperture, falls outside of the front condenser surface, the corners of the pictures on the screen will be dark. The remedy is to move the motion head as a whole nearer to the condensers, even though this change should bring the focal center of the motion-picture lens nearer to the condensers than the focal center of the lantern slide lens, and thereby require a change from the motion head to the stereo lens, or back.

For the best lighting of the screen, the front condenser should be as long as possible, but should be a little shorter than the limit, since the exact limit is hard for the operator to work satisfactorily, and a condenser a little too long is much worse for the picture than one a little too short.

Short Rules for Condenser Lengths. *The front condenser glass shall have a focal length two inches less than the distance from the middle of the condenser box to the middle of the motion-picture objective lens. The back condenser should be five and one-half inches in focal length.*

The back condenser may be four and one-half inches to force the light upon the picture screen at the risk of breaking more condensers.

The back condenser may be six and one-half inches to reduce the breakage of condensers at the cost of a slight reduction of the brightness of the picture screen.

When the front condenser is too short, the correction cannot be accomplished by substituting the back glass with one a little longer.

Use the longest focal length (the thinnest glass) for the front glass of the condensers.

Lenses. The motion-picture lens is similar to the stereopticon or fixed picture lens in all respects except in that of focal length. It is similar in focal length, too, so far as the fundamental principles of projection are concerned, and its focal length, size of picture produced, and required length of throw may be determined by the rules, both for approximation and exactness, which have been given in connection with the discussion of lenses for stereopticon work.

TABLE I

Showing Size of Screen Image When Moving Picture Films Are Projected

Size of Mask Opening $\frac{11}{16}$ by $\frac{15}{16}$ inch

Equiv. Focus Inches	15 ft.	20 ft.	25 ft.	30 ft.	35 ft.	40 ft.	45 ft.	50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.
$2\frac{1}{8}$	4.8	6.4	8.0	9.6	11.3	12.9	14.5	16.1					
	6.5	8.7	11.0	13.2	15.4	17.6	19.8	22.0					
$2\frac{1}{2}$		5.4	6.8	8.2	9.6	10.9	12.3	13.7	16.4				
		7.4	9.3	11.2	13.1	14.9	16.8	18.7	22.4				
3		4.5	5.7	6.8	8.0	9.1	10.3	11.4	13.7	16.0			
		6.2	7.7	9.3	10.9	12.4	14.0	15.6	18.7	21.8			
$3\frac{1}{2}$			4.9	5.8	6.8	7.8	8.8	9.8	11.7	13.7	15.7		
			6.6	8.0	9.3	10.6	12.0	13.3	16.0	18.7	21.4		
4			4 2	5.1	6 0	6.8	7.7	8.5	10.3	12.0	13.7	15.4	
			5.8	7.0	8.1	9.3	10.5	11.6	14.0	16.3	18.7	21.0	
$4\frac{1}{2}$				4.5	5.3	6.2	6.8	7.7	9.1	10.6	12.2	13.7	15.4
				6.2	7.2	8.4	9.3	10.5	12.4	14.5	16.6	18.7	21.0
5					4.8	5.4	6.1	6.8	8.2	9.6	10.9	12.3	13.7
					6.5	7.4	8.4	9 3	11.2	13.0	14.9	16.8	18.7
$5\frac{1}{2}$					4.3	4.9	5 6	6.2	7.4	8.7	9.9	11.2	12.4
					5.9	6.7	7.6	8.4	10.2	11.9	13.6	15.3	17.0
6						4.5	5 1	5.7	6.8	8.0	9.1	10.3	11.4
						6.2	7.0	7.7	9.3	10.9	12.4	14.0	15.6
$6\frac{1}{2}$							4 7	5.2	6.3	7.3	8.4	9.6	10.6
							6.4	7.1	8.6	10.0	11.4	13.0	14.5
7							4.4	4 9	5.8	6.8	7.8	8.8	9.8
							6.0	6.6	8.0	9.3	10.6	12.0	13.3
$7\frac{1}{2}$								4.5	5.4	6.4	7.3	8.2	9.1
								6.2	7.4	8.7	10.0	11.2	12.3
8									5.1	6.0	6.8	7.7	8.5
									7.0	8.1	9.3	10.5	11.6

The difference between the size of the lantern-slide window or the mask window of the slide, and the motion-picture window, must be borne in mind. The size of lantern slide usually calculated for in computing lens dimensions is $2\frac{3}{4}$ inches by 3 inches, a dimension which is exceeded in many slides. In the matter of the motion picture as commercially used in the theater, the size of the window for projection is called $\frac{3}{4}$ inch by 1 inch, is never more than that, and is never less than $\frac{11}{16}$ by $\frac{15}{16}$ inch.

The projected picture of the motion-picture film always is about three-quarters as high as it is wide, and this proportion must be taken into consideration when calculating upon the dimensions of the picture which is to be thrown upon the picture screen.

The desirable results of operating lantern slides with a slide-carrier window mask have been discussed in connection with the operation of the optical lantern for fixed slides. The same good results are obtained in motion pictures by the use of a window mask in the window of the film gate, the aperture plate, as it is called, having an aperture just a little smaller than the pictures upon the film, so that the side lines of the picture upon the screen are formed not by the film picture but by the aperture plate of the motion head. Most projecting machines are equipped with an aperture plate which "trims" the picture $\frac{1}{32}$ inch all around, reducing the size of the visible picture to $\frac{11}{16}$ by $\frac{15}{16}$ inch.

Table I gives the size of projected picture with different lengths of throw and with different focal lengths of projecting lenses with an aperture or mask opening $\frac{11}{16}$ by $\frac{15}{16}$ inch.

At the left in the first column is given the lengths of the lenses, from $2\frac{1}{8}$ inches to 8 inches, for which the table is computed. The columns at the right of the first column are arranged for the different lengths of throw, the length of throw considered in each column being mentioned at the top of that column.

For each length of lens, there are two figures in the columns for length of throw. These two figures are the height and width upon the screen of the projected picture which will be secured by using the length of lens mentioned at the left of the pair of figures and using it with the throw mentioned at the top, above the pair of figures.

From Table I may be obtained:

The lens length required to give a desired picture when the throw is known.

The size of picture which will be given by any certain lens when the throw is known.

The length of throw to be taken to secure a picture of a desired size with any certain lens.

To Take Lens Length. Find in the table the length of throw which you have. This will be found as the number of feet mentioned at the top of one of the columns. Now look down in this column until a pair of figures is found giving the size of picture which you desire to project. When this pair of figures is found, lay a card

ARRIVAL OF THE BOSS
Scene from Photoplay, "Circle C's New Boss"
Courtesy of the *Champion Film Company, New York*

SCENE FROM PHOTOPLAY, "THE HERDERS"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

across the book page, even with the lines and just showing above its edge the pair of figures showing the desired size of picture in the proper length of throw column. At the left of the lens table and just above the edge of the card will be the length of focus in inches of the lens required for that size of picture.

Example. You have a 70-foot throw, and desire a picture about 12 feet wide. Finding the column marked at the top 70 feet and looking down that column, the pair of figures, 8.7 by 11.9 is found, and placing a card on the page the figure $5\frac{1}{2}$ is seen at the left above the edge of the card. An objective lens of $5\frac{1}{2}$ inches equivalent focal length will give a picture about 8 feet 9 inches high by about 11 feet $10\frac{1}{2}$ inches wide.

To Take the Picture Size. In this problem, you have the lens which you are thinking of using, or must use, and you have the length of throw over which it must be used. At the left of the page, find the focal length of the lens in inches, either as marked on the lens, or as measured as described for stereo lenses for the optical lantern. Place a card across the page just below the figure of the length of lens, so that the card will show above its edge a row of pairs of figures of which in each pair the lower figure of the pair will be the larger figure. Now find the length of throw at the top of the narrow columns, and under that length and at the edge of the card will be found the pair of figures which tell the height and width of the projected picture when that lens is used over that throw.

Example. You have a 4-inch lens and a 40-foot throw and desire to know what size of picture will be projected. At the left of the page find the figure 4 and place a card across the page so that it will show the row of figures beginning with 5.8 and ending with 21.0, thus showing a double row of pairs of which the lower figure of each pair is the larger of the pair. Now find 40 feet at the top of one of the narrow columns and below it is found the pair of figures, 6.8—9.3, meaning that with that lens and that throw the picture will be 6 feet $9\frac{1}{2}$ inches in height and 9 feet $3\frac{1}{2}$ inches in width.

To Take the Length of Throw. Knowing the lens which must be used and the size of picture desired, look at the left of the table for the lens length, place a card across the page and look along the card for the size of picture, then go up the column to the top and there will be found the length of throw which will give that size picture with that lens.

Example. In a parlor, a screen 6 feet square has been provided; you have only a 4-inch lens. At the left of the page, find the figure 4 and lay a card across the page; the first pair of figures along the edge of the card is

4.2–5.8, which will go on the screen, but the next pair, 5.1–7.0, will give a picture too large for the screen. It is seen, therefore, that the operator must not place his projecting machine farther away than 25 feet (the figure at top of column above the pair, 4.2–5.8) or the projected picture will be too large for the screen.

Accurate Calculations. When sizes are needed very accurately, they should be calculated according to the rules given for calculating data for lenses for lantern slides for the optical lantern, using the three equations:

$$ST = PD \qquad (1)$$

$$F^2 = (D - F)(T - F) \qquad (2)$$

$$D + T = H \qquad (2)$$

In these equations, when used in the calculation of dàta for motion picture projection,

S equals the width of the film aperture or mask opening when calculating for the width of the projected picture—make S equal to 1 inch or $\frac{15}{16}$ inch according to the dimension of the aperture—and equals the height of the film aperture when calculating for the height of the projected picture—make S equal to $\frac{3}{4}$ inch or $\frac{11}{16}$ inch, according to the dimension of the aperture.

T equals the length of throw, lens to screen, which may be measured closely when the length of the lens is known approximately, and when T may be measured the equation for S may be written in a simpler form if desired.

P equals the picture dimension as projected on the screen, being the height when S is the height and being the width when S is the width of the film aperture.

D equals the distance from the focal center of the lens to the picture film in the film window; it is not required to be known in the course of calculations, but is included in the equations because it influences the size of the projected picture, sometimes as much as 1 inch in the width of a picture 12 feet wide.

F equals the focal length in inches of the motion-picture objective or projecting lens.

H equals the distance, screen to film.

Approximate Calculations. Use the formulas or equations given for lantern slides. These calculations are useful when the exact length of throw is not given in the table.

The *throw* equals the desired picture width multiplied by the focal length of the lens and divided by the film aperture width, all dimensions taken in inches. That is

$$T = P \times F \div S$$

The *lens length* equals the film aperture width multiplied by the length of throw and divided by the desired picture width, all dimensions taken in inches. That is

$$F = S \times T \div P$$

The *picture width* equals the film aperture width multiplied by the length of throw and divided by the focal length of the lens, all dimensions taken in inches. That is

$$P = S \times T \div F$$

The *picture height* equals the film aperture height multiplied by the length of throw and divided by the focal length of the lens, all dimensions taken in inches. That is

$$P = S \times T \div F$$

Calculations Compared. Assume a 4-inch lens and a 48-foot throw. The accurate calculation gives a picture size of 11 feet 11 inches, while the simpler approximate calculation gives a picture size of 12 feet, approximating the true picture size within 1 inch.

Matched Lenses—Stereo and Motion Head. By the term *matched lenses* is meant a pair of lenses selected to work together, the one as a motion-head lens and the other as a stereo lens, and to give two pictures upon the screen which shall have the desired relation in size.

Lenses may be matched for height, for width, or for area. If the screen is square, the stereo lens may be matched to project a picture as wide as the motion picture lens. If the screen is the shape of the motion picture, then the stereo lens may not project a picture higher than the motion-picture projection. If the screen is between the two, or if it is ample in size and the operator prefers a picture of equal area, the lenses may be so matched. The argument in favor of equal area is that the shift from lantern slide to motion film is less objectionable to the operator, but when the possible difference in densities is considered this objection seems to have little force.

To match lenses for the same width of picture on the screen, the stereo lens will be just three times the focal length of the motion picture lens, figuring 1 inch as the width of the window in the film gate and 3 inches as the width of the mask opening of the lantern slide. With the $\frac{15}{16}$-inch film window, the stereo lens should have three and one-fifth times the focal length of the motion-head lens.

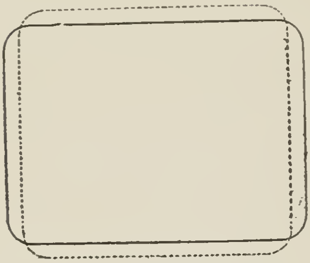


Fig. 5. Diagram of Edges of Pictures on Screen with Lenses Matched to Give Equal Area

For equal height of picture on the screen, $\frac{3}{4}$-inch high film window, and $2\frac{3}{4}$-inch high lantern slide mask opening, the stereo lens should be three and two-thirds the focal length of the motion-head lens; and with a film window $\frac{11}{16}$ inch, the stereo lens should be four times the focal length of the motion lens.

For equal areas, the stereo lens should be three and one-third times the focal length of the motion-head lens for a film window $\frac{3}{4}$ inch by 1 inch or full size of the motion film. The stereo lens should be about three and three-fifths the focal length of the motion-head lens for a film window $\frac{11}{16}$ inch by $\frac{15}{16}$ inch. The arrangement or relation of the two pictures upon the picture screen when projected matched for area is shown in Fig. 5.

Adjustable Lenses. These lenses are made to change the equivalent focal length of the lens by turning the front rim of the lens, Fig. 6. The knob moves the whole lens. Such a lens, at a 40-foot throw, will project a picture varying, say, from 8 feet in width to 14 feet in width; that is to say, its focal length can be adjusted from $2\frac{1}{2}$ inches to nearly 5 inches by turning the front rim. After turning the front rim to change the picture size, the lens must be readjusted with the knurled knob to focus properly on the screen. The price is as much as two or three ordinary lenses of the same quality. Any lens will project its picture slightly smaller by unscrewing front and back lens cells a few turns of the screws. This is not to be recommended for indiscriminate practice.

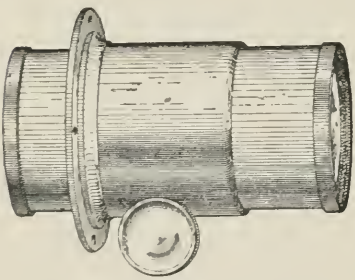


Fig. 6. A Lens Having Adjustable Focal Length, for Motion Head

THE SHUTTER

In projection by persistence of vision, the secret of successful work is to make the change of picture on the screen without permitting the spectator to see or to appreciate the change in any way other than by the shift of the moving objects in the image portrayed. Theoretically, it is possible to shift the picture by a jerk so quick that the transfer from the old to the new picture is made without leaving upon the eye of the spectator an impression of motion of the fixed objects because the motion was so brief.

That this is possible is proven by the successful operation of many shutterless toy projectors, projecting film of standard dimensions by means of an oil lamp upon a small screen, such as 3×4 feet. The picture is steady and flickerless. The result is dependent upon the weak illumination of the oil lamp. When a miniature incandescent lamp is placed in such a toy machine and caused to glow brightly by a sufficient battery, thereby increasing the intensity of illumination upon the screen, the shifting becomes apparent at once, manifesting itself by "rain" or "light rain," sometimes called "halo." This is a streaking of the picture vertically, caused by the rapid passing of the light spots of the pictures while moving.

To avoid "light rain," the motion head is provided with a shutter for cutting off the light from the picture screen while the film is in motion during the shift. This obscures the "light rain" and gives again a satisfactory projection, until the intensity of illumination is increased further, when the picture change begins to become apparent again, this time by a flickering of the illumination of the screen every time the shutter cuts off the light for the change.

To make the flicker less noticeable, effort is made to reduce the time of the dark interval until it falls within the limits of persistence of vision. With the widely used "Geneva" movement for the intermittent mechanism, it is feasible to have the film stand still four-fifths of the total picture time of one-fourteenth of a second, making the change of pictures in the remainder of one-fifth of one-fourteenth of a second, or in one-seventieth of a second; but the shutter begins to cut off the light before the film begins to move and then does not restore the full light until after the film has come to rest, thus lengthening the interval of reduced light. Furthermore, the more intense the screen illumination, the more noticeable is the flicker for the same shutter setting and the same machine speed, indicating that the brilliancy of the picture screen has some effect upon the time during which the vision will persist.

In the same audience, one person will see flickering pictures where another will not, because of the difference in the eyes. Successive scenes in the same reel of film will show flicker or not to the same spectator because of the difference in the opacity of the film image. A scene with a bright white sky will flicker unendurably to nearly all eyes while the interior view following it will run smoothly because of the smaller amount of light on the screen.

The multiple shutter is an invention for reducing flicker. It is used on many prominent machines. The form may be disk, barrel, or cone. The principle is that of shutting off the light twice, or three times for each picture projected, so that the rapidity of flicker is increased until the flicker becomes so fast that the eye cannot appreciate the separate flickerings and blends them all together into a continuous steady illumination by reason of the persistence of vision. In the operation of this shutter, the light is cut off from the screen forty-two times per second and the picture is changed to the next step of the film only fourteen times per second, or every third time the light is cut off.

With a shutter having but one blade, cutting the light from the screen only when the picture is being changed, four-fifths of the light of the lantern is projected to the screen. With the multiple shutter which shuts off one-sixth, then leaves the light on one-sixth, then shuts off one-sixth, and so on, the light given to the screen is three-sixths on and three-sixths off for every picture, giving but one-half of the lantern's light to the screen. Thus the multiple shutter reduces the maximum illumination and thereby reduces the flicker, even as flicker would be reduced if the operator would reduce the current through his arc and give a less bright projection in that way. The multiple shutter much improves the projection in the detail of flicker.

Adjust the shutter accurately, whether single or multiple wing and keep the machine running fast enough to keep the flicker subdued. In scenes which have a particularly bright screen illumination, the light may be reduced by a *tinter*, which is a sheet of colored glass or a plain colored lantern slide or the equivalent, which may be held either between the lens and the screen or between the condensers and the film window

Types of Shutters. There are two principal types of shutters, the barrel shutter and the disk shutter, the latter amplified to the double-disk shutter to secure the advantages of the barrel type.

Barrel Shutter. The barrel shutter is shown in Fig. 7. This shutter is like a barrel with two windows cut in it. When it is arranged to shut off the light as a single shutter, cutting the screen dark once for each picture shift, then it revolves at one-half the speed of the intermittent mechanism, or one revolution of the shutter for two pictures. The light is admitted to the screen when the two windows of the barrel are opposite each other horizontally. The advantage which this shutter has over the disk is the speed with which it cuts the light from the screen and restores it after the shift. The blade near the lens begins to cut the upper rays and the blade near the film window begins to cut the lower rays, and when the shutter is half over the beam of light, the light has been shut off, because the shutter has worked upon both halves at the same time. In like manner, when the shutter begins to admit the light to the screen again, it begins at the middle and as the blades separate the light spreads upon the lens rapidly toward the upper and lower edges, restoring the full illumination very quickly. This shutter usually is placed between the lens and the film window, as shown in the diagram. For the multiple-shutter effect, the barrel shutter revolves once for each picture, cutting the light off twice. The blades then are wider, the windows smaller.

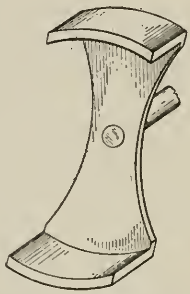


Fig. 7. The Barrel Type of Shutter

Disk Shutter. The disk shutter is a plain disk with a window in it, or a hub with a single wing attached, revolving edgewise as shown in Fig. 8. It is placed in any one of three places—between the lens and the film window; between the condensers and the film window; or before the lens. It is desirable that the light be cut off as quick as possible when the shutter begins to cut it off, and that it be restored just as quickly when the shutter begins to restore it. This advantage was enjoyed by the barrel shutter over the disk shutter so long as the disk shutter remained of small radius; the small radius was enforced when the shutter was placed between the lens and the film window because it must be contained then within the body of the projecting machine; when placed between the film window and the condensers, its size was restricted also, because on the one hand it conflicted with the crank, and on the other hand with the stereo-lens beam of light.

Before the Lens Shutter. The before-the-lens shutter solved the problem of the quick cut off for the light with the simple disk shutter.

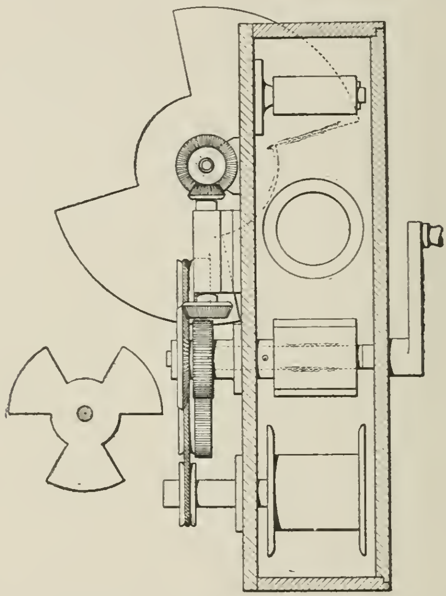


Fig. 8. The Disk Type of Shutter, with Two and Three Wings

The shutter was placed before the lens and was made of large radius. The speed of the shutter near the edge of a 15-inch disk is seven times that of the shutter within the motion head which had an axis only 2 inches from the optical axis of the beam of light, and when the edge of the wing comes to the beam of light streaming from the lens, the beam is cut very quickly. True, the beam of light at this point is larger than it is between the lens and the film window, but the speed of the cutting shutter wing is still greater in proportion.

With the disk shutter for the multiple shutter effect, it may carry three wings, each one-sixth of the circumference of the shutter, or the shutter of two wings may be driven at one and one-half times the rate of the picture shift to reduce the flicker, Fig. 8.

Any shutter may give the multiple shutter effect to reduce the flicker by doubling the speed, where the mechanical details of the motion head permit it.

Multiple-Disk Shutter. This is a shutter consisting of two disks revolving in opposite directions, so that they begin at the same time to cut off the light from both edges of the beam, just as the barrel shutter does. This makes the cut-off still more quickly than the single-disk shutter and serves still further to reduce the flicker. In multiple-disk shutters the disks are not always mounted upon the same shaft or upon the same axis, one disk sometimes working from one side of the beam of light and the other disk from the other side.

Cone Shutter. With its driving shaft set at an angle of 45° to the beam of light, the cone shutter revolves its two wings—one in the beam of light and the other at the side—parallel with the beam. The cone shutter is a shape adapted to save space in the motion head, and give the advantages of the disk without taking the room.

Setting the Shutter. Here is a short rule which applies to every type of shutter and to every type of intermittent mechanism:

Place a piece of film in the motion head, threaded through the film gate and intermittent feed of whatever nature, and frame the picture true in the film aperture, splitting the margin of trim if you are running a 11/16 aperture on a ¾″ picture. Then advance the intermittent mechanism until the film is being shifted and is exactly in the middle of the shift. At this point, the line of division of the film between the two pictures will be exactly across the middle of the film window. Now set the shutter so that it is dead center over the lens, or dead center on the optical axis.

If you have a multiple shutter and one of the leaves of the shutter is broader than the others, or if one is opaque and the others translucent, then the broad leaf or the opaque leaf is the one to set over the lens when the film is half shifted.

Another rule, which applies only to the Geneva shift and the disk shutter, is:

When the pin is half in the slot, the shutter should be half over the lens.

Fire Shutter. The fire shutter, or safety shutter, shown at *N* in Fig. 4, is a requirement of most city ordinances. It is a shutter for cutting the rays of the arc lamp from the film window when the motion head is not running. It is called *automatic* when it is so arranged that it will fall into place and cut off the light when the film stops, without requiring the attention of the operator to close it. Sometimes its mechanism is such that when the handle is turned it is lifted from the film window automatically, and sometimes it is such that a definite speed must be attained before it will be lifted from the film window.

This fire shutter is a detail which varies greatly with different makes of motion heads. Its general purpose is the same in all—to protect the film from the intense heat of the arc in case the film should stop in the film window, for the arc would cause the film to burst into flame in a few seconds.

FILM GATE

The mechanism of the film gate is so simple that unless its *functions* or the duties dependent upon it are understood the projection operator is liable to neglect it. It is one of the very important parts to be kept in exact condition of adjustment and to be corrected when the slightest wear shows, for one of its duties is the *keeping* of the focus constant upon the screen. It is of little use to adjust the objective lens to focus the film upon the screen in one minute when the film gate will change the position of the film and throw it out of focus the next.

Functions. The functions of the film gate are: *First,* to guide the film so as to prevent any sidewise motion as it passes in front of the film window in the aperture plate.

Second, to flatten the film at the film window and hold it flat so that all of the surface of the film picture may be thrown into focus upon the picture screen by a flat-field lens, and to hold it in the same plane all the time so that the focus when once established by the adjustment of the objective lens will be maintained to the end of the reel and through successive reels.

Third, to prevent vertical jiggling of the images of the series in their comparative locations in the film window, by putting upon the film a tension or restraint to keep it from following by its momentum after the intermittent mechanism has stopped pulling.

Construction. The main plate has two side guides or rails and a film aperture or film window. The two side rails are separated sufficiently to permit the film to pass between but not to take any diagonal position. When threading up the machine, the film is placed in the groove formed by the face of the film gate and the two shoulders or rails forming the side guides for the film; and the tension plate or tension springs are brought to bear upon the edges of the film.

In Fig. 4, the body of the film gate is represented at *G* and the tension plate at *H*. The springs are not shown.

Adjustment of Tension Springs. Where the tension springs do not make direct pressure upon the edges of the film, the tension plate is pressed by tension springs which are adjustable. If the tension of these springs is too tight, they will drag the film at such strain that a weak place or splice will separate under the pull of the intermittent feed; if the tension of the springs is too loose, the picture will "follow" and the projected image upon the screen will jiggle vertically. As the tight spring does not manifest itself unless it be by tearing the film or causing the handle to turn hard, it is less easily detected upon inspection than the loose spring, which permits the picture to jiggle. The adjustment of the tension springs may be attained, therefore, first by setting all of them to the same tension, then by loosening them equally until the picture begins to show upon the screen that the tension springs are too loose; then by tightening them until the picture is steady again. Thus they will be tight enough, without excess pressure.

Care. The film gate and the tension plate both wear where the film rubs between them; where the springs press directly upon the film, the springs themselves wear. Any wear which can be detected will probably be enough to throw the picture out of focus upon the screen from time to time, particularly a film which is slightly warped.

The only remedy for a worn film gate, which permits the focus of the picture to vary from time to time as the reel is turned through, and the lens remains stationary, is to buy new parts—gate body (with some makes of machines it is the "aperture plate"), or new tension plate, or springs, or all of them.

Wear can be reduced and the machine will pull easier on the handle if the film gate and tension plate surfaces, which are rubbed by the film, are kept free from any gelatine which may come off of the film. Clean them every time by wiping before threading up the new reel, and by wiping with an oily rag every time a new reel is put in—the rag should be oily but so dry that it is not running oil when squeezed in the hand. Never oil them with an oil can.

FILM SHIFT OR INTERMITTENT MOVEMENT

There are many variations in devices for stepping the strip of film forward the three-quarters of an inch from one picture to the next of the series. The requirement of such a device is very severe, for the step must be made with great speed and with great accuracy, and furthermore the film must be permitted to remain perfectly motionless during the interval between steps. A class of projectors, which does not use the intermittent movement, will be considered in connection with continuous projection devices.

The different mechanisms for making the shift of the film upon the step-by-step principle are: the sprocket; the pin; the claw; the beater; and the intermittent grip.

Intermittent Sprocket. The intermittent sprocket is a wheel with two circles of pointed teeth spaced a trifle more than 1 inch apart upon the surface of a drum about 1 inch in diameter, or spaced upon two hubs or bosses to hold them at that distance, the metal being cut away to render the wheel light of weight and easily started and stopped. The sprocket teeth are spaced so as to engage the perforations of the edges of the film strip, and the film is advanced step by step by turning the sprocket wheel intermittently, usually one-quarter of a revolution for each step of the film.

For turning the sprocket wheel in its intermittent motion, a large variety of devices have been employed, and a new one is brought out occasionally. The only test for a new intermittent movement is the test of time. Nearly all intermittents ever used have given place to the Geneva, which was among the earliest of them all.

Geneva or Pin-and-Star. The Geneva movement comprises a star wheel shaped like a modified Maltese cross and attached to the sprocket shaft, and a pin wheel which revolves steadily. Every time the pin comes around it catches a wing of the Maltese cross and throws the cross around one-quarter of a turn, leaving it there until the pin comes around again.

A Geneva movement—it is called *Geneva* because it was used first in Geneva, Switzerland, in watches, with one of the wings of the cross convex instead of concave so that the main spring of the watch could not be wound too far—is shown in perspective view in Fig. 9. At the left is the star wheel, with four slots and four wings each having a concave outer face, as indicated at *A*. The pin wheel is seen at the right, and consists of a flat disk or face plate carrying a pin *B* and the cam band *C*. The cam band is cut away on both sides of the pin and the pin is set outside of the cam band circle, or a little farther from the center hole of the disk. When the pin wheel revolves, toward the left, say—although it depends upon the particular projecting machine or camera inspected, for the Geneva movement may be on either end of the intermittent sprocket shaft—the pin moves toward the left and when the pin comes to the star wheel it enters the open end of the slot next to the wing which has been against the moving cam band; but the cam band now has released that wing and the pin in moving into the slot presses against the side of the wing and turns the star wheel as two meshing gear wheels would turn each other, except that the pin starts the star wheel slowly, swings it rapidly during the middle portion of its movement, and again slows it up to a standstill before leaving the slot. The pin enters the slot, which is shown diagonally upward to the right, and having turned the star one-quarter of a revolution the pin leaves the same slot diagonally downward to the right, the cam bend having come around following the pin to engage the concave surface of the next wing before the pin has left the slot entirely.

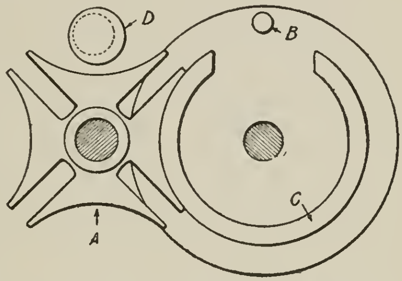


Fig. 9. Geneva Intermittent Movement

The advantages of the Geneva movement are: (1) It starts the film with a slow movement, increasing the speed to a maximum, then decreasing the speed until the film comes slowly to rest. (2) It holds the film or sprocket firmly locked during the interval of rest between shifts. (3) It is very easy in the wear of the sprocket holes of the film because of the lack of jerk in starting the film. (4) It is very gentle with weak or injured places in the film which might yield and permit the film to be torn apart if suddenly jerked. (5) It is capable of construction in such proportions that any desired ratio of time of movement as compared with time of rest may be attained.

To change the ratio of movement and rest of the sprocket wheel and film, the relative diameters of the two wheels are changed. With a larger diameter of pin wheel, the breadth of the wing surface *A* which rests upon the cam band will be a smaller part of the whole circumference, hence the pin *B* must affect the shift of the star wheel, sprocket, and film during a smaller proportion of its total travel, or of one revolution. The ratio between the diameters of the two wheels determines the ratio of movement to rest, the ratio of rotation being four of the pin wheel to one of the star wheel in any case, regardless of the relative diameters of the wheels.

Double Star. The double star movement consists of two Geneva movements working in the same machine, one above the film gate and one below the film gate. The theory is that they assist in keeping the film flat by keeping it taut between them, also that they reduce the strain upon the film by giving the lower sprocket less pulling to do. This mechanism sometimes operates both star wheels from one pin wheel, in which case there are two pins in the pin wheel, the two pins operating the two stars simultaneously.

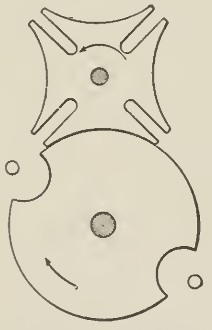


Fig. 10. Double-Pin Geneva Intermitten Movement

Double Pin. The double pin movement is merely a modification of the Geneva movement by which the star wheel takes a step every half revolution of the pin wheel, instead of every full revolution. It is shown in diagram in Fig. 10. The only advantage urged is that the speed of the pin wheel is reduced to half that required were the single pin used. The simple Geneva is the more widely adopted.

Pitman. The pitman movement is illustrated in Fig. 11. The intermittent sprocket is carried by the shaft carrying the ratchet wheel *R*. Since the ratchet in the figure is shown with seven teeth, the sprocket attached would require twenty-eight teeth to feed the standard four-hole film. The wheel *C* is the constant drive, and the face of the wheel *C* carries a wrist pin driving a pitman bar, which in turn drives the pawl engaging into the ratchet R. The pawl upon the top of the ratchet R prevents return of the ratchet during the return stroke of the pitman and driving pawl. As the wheel C may be designed to drive the pawl over a greater stroke than the distance between two ratchet teeth, this device also may have a designed ratio of time of movement to time of rest; unless the movement is approximately half-and-half the start of the film will be a sudden jerk.

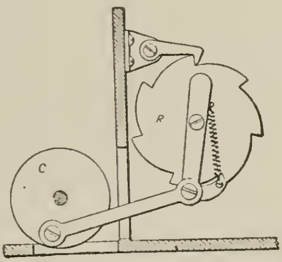


Fig. 11. Pitman Intermittent Movement

Ratchet. The ratchet movement is illustrated in Fig. 12. The sprocket wheel is attached to the same shaft as the ratchet wheel M and the ratchet-shape wheel N is driven steadily. The wheels move in the same direction, as is indicated by the arrows, and they are connected by a volute spring. With six teeth in the ratchets, the sprocket would have twenty-four teeth for a standard film. The pawl N swings upon a fixed pivot and engages both of the toothed wheels. Its function is to hold the intermittent wheel M at rest until the pawl is lifted by the steady drive N, at which time the pawl slips the tooth of the intermittent, but in turn slips a tooth of the steady drive so soon thereafter that it drops toward the intermittent wheel to engage the next tooth of that wheel and to hold it at rest until the next release, as compelled by the steady drive N. The film is started by this mechanism gently by the power of the spring connecting the two wheels M and N, but it is brought to rest with a jerk by the engagement of the intermittent wheel M with the pawl P.

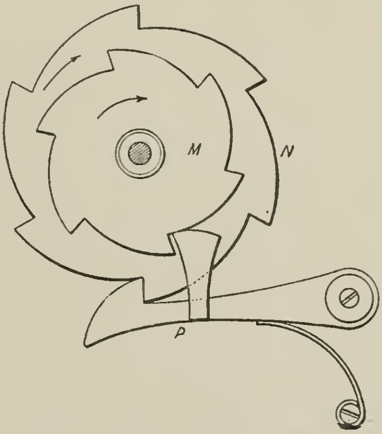


Fig. 12. Ratchet Intermittent Movement

Drunken=Screw. The drunken-screw intermittent movement involves a mechanism which is substantially a worm and wormwheel, but the worm, instead of being inclined through its full length, is straight for the greater part of the circumference and then has a

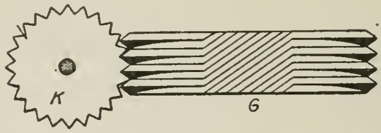


Fig. 13. Drunken-Screw Intermittent Movement

sharp angle. The wormwheel, therefore, stands at rest during the passing of the straight portion of the worm thread, and moves rapidly during the passage of the inclined portion of the thread. The worm-wheel, which is shown at K in Fig. 13, is attached to the intermittent shaft, and the drunken screw or worm G of that figure is steadily driven.

Snail. The snail intermittent movement comprises two wheels normally out of engagement, one of which engages a projection of the other with an inclined edge which propels the companion wheel through a required angle. This movement is shown in Fig. 14. The intermittent wheel P is provided with a number of pins, and the snail S engages a pin at every revolution and forces the intermittent wheel P through the desired angle.

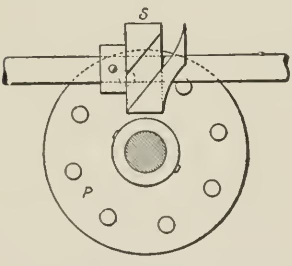


Fig. 14. Snail Intermittent Movement

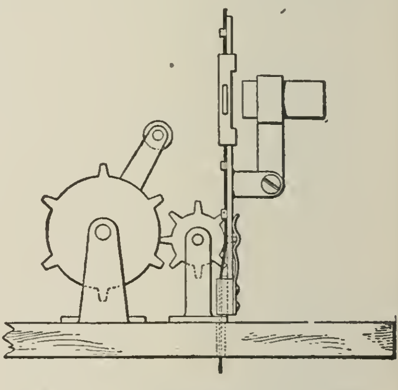


Fig. 15. Spring-Latch Intermittent Movement

Spring Latch. The spring latch intermittent movement has as its distinctive feature the holding and centering of the sprocket for each film picture by means of a bent spring which engages either one tooth, by a notch in the face of the spring, or two teeth of the wheel, by dropping between them with two inclined faces. When

ROSE STANDS BETWEEN LOVE AND DUTY
Scene from Photoplay, "The Spring Round Up"
Courtesy of *G. Melies Company, New York*

such a wheel is pushed over the apex of the spring it is propelled by the spring to its next position of rest and held there until again propelled by the steady drive. Such an intermittent movement is shown in Fig. 15. The smaller wheel is the film sprocket wheel, or fixed to the film sprocket shaft, while the larger wheel propels it intermittently, making a step every time a tooth of the large wheel engages a tooth of the small wheel.

Single-Sprocket. The single-sprocket intermittent movement is shown in Fig. 16, which really is a revolving claw movement. The

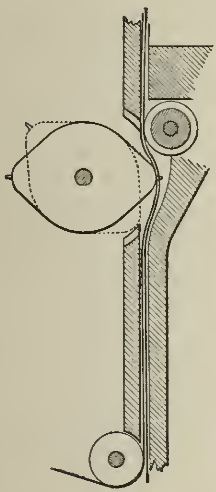


Fig. 16. Single Sprocket Intermittent Movement

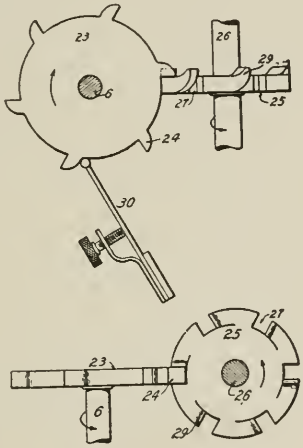


Fig. 17. Modified Drunken-Screw Intermittent Movement, End and Top Views

sprocket wheel moves with steady rotation and has two pairs of teeth. As the first of these pairs of teeth swing against the film, they engage the holes in the edge of the film and drag it down, leaving the film unengaged until the other pair of teeth come into engagement for the next shift.

Modified Drunken-Screw. A modified drunken-screw intermittent movement is shown in Fig. 17. The intermittent wheel *23* tends to move by friction clutch from the main drive, in the direction of the arrow. It is prevented from movement, however, by the engagement of its teeth *24* with the face of the steady drive wheel *25*, which has the upwardly turned wings *29*. The steady drive shaft is *26*, the intermittent shaft is *6*. The spring *30* holds the wheel *23* against the face of the wheel *25* and prevents backlash, locking the film steady during the intervals of rest. When the next tooth *29* of the wheel *25* comes to the tooth of the wheel *23*, the wheel *23* is started with a blow and travels under its friction clutch until the next tooth engages the face of the wheel *25*. Fig. 17 shows a view of the face of the intermittent wheel *23* and the edge of the steady drive wheel *25* in the upper drawing, and the edge of the intermittent wheel *23* and the face of the steady drive wheel *25* in the lower drawing. The arrows show the direction of rotation.

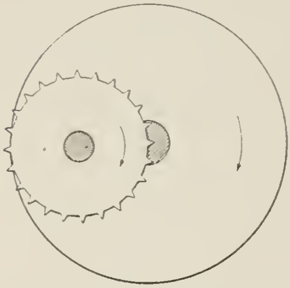


Fig. 18. Eccentric Sprocket or Epicycloidal Intermittent Movement

Eccentric Sprocket. If the lower sprocket-roller of a machine revolves continuously on a fixed axis, it will, of course, continue to draw down film. If, however, it is mounted so that while it revolves its axis also rotates eccentrically about a radius equal to the radius of the sprocket, the film will be moved intermittently, the sprocket simply rolling up along the film for part of a revolution without moving it. Fig. 18 shows its arrangement as it is used in the Prestwich camera. The sprocket is driven by a train of gears.

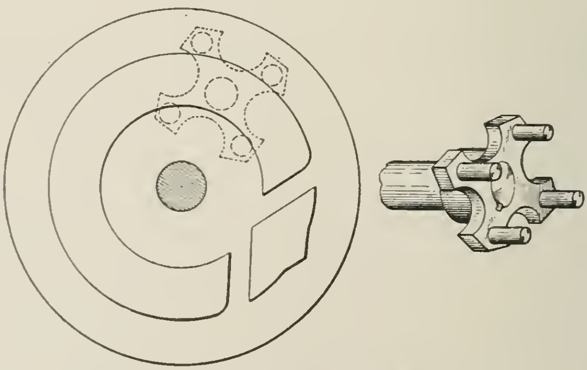


Fig. 19. Pin-Cross Intermittent Mechanism

Pin-Cross. The pin-cross intermittent mechanism shown in Fig. 19 has been offered lately. Its construction seems to indicate strength; the design of the cam band indicates that the shift is made in a very small proportion of the total time of revolution. It is, therefore, a movement bearing promise, to be proven by use. The movement is so new that it still lacks an accepted name, but the name pin-cross seems to be descriptive. In this movement, the member shown separated at the right, consisting of a cross of four arms, each of which bears a pin, is the member attached to the intermittent sprocket shaft. Thus attached, it meshes into the cam wheel at the left, as shown in dotted lines. When the broken or active part of the cam band reaches the pin-cross, the slight projection upon the outer edge of the small cam between the ends of the band throws the leading outside pin outward, drawing the leading inside pin into the slot before the end of the cam band, the following outside pin also taking the cross path after the end of the cam band, the following inside pin becoming the leading inside pin and the leading outside pin becoming the following outside pin. Thus, the pin-cross is turned one-quarter of a revolution, to shift the film, and is held rigid by engagement with the cam band at four points, by the four pins, until the cam wheel has completed another revolution and has come to the point for initiating another shift. Silence is one of the claims for this new movement. It is used on the Power's Cameragraph No. 6, which is advertised to give the complete film shift in one-ninety-sixth of a second, giving the complete shift of the film in one-sixth of a picture interval and running sixteen pictures per second, if desired.

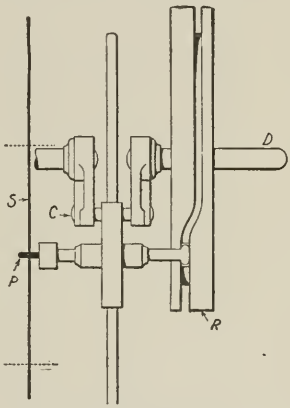


Fig. 20. Theory of Pin Intermittent Movement

Pin. Pin intermittent movements are those in which the teeth engaging the holes in the film are not the teeth of a sprocket wheel, but are teeth fixed to some reciprocating member which gives them the four movements necessary to control the film with pins, namely, (*1*) to advance the pins into the holes of the film, (*2*) to move downward, dragging the film, (*3*) to withdraw the pins from the holes in the film, and (*4*) to return to the point of starting in readiness for advancing into the next holes of the film to repeat the cycle.

Fig. 20 shows the theory of such a film movement. The pins *P* are carried vertically by the action of the crank *C* of the steady drive shaft *D*, which shaft carries also the cam wheel *R* in the edge of which is a groove which controls the pins *P* for their lateral movement, advancing them into the film holes and withdrawing them as required. The slot of the cam wheel *R* is straight except in two places, for advancing and retreating the pins, one of the inclined places of the cam slot being shown in the figure just above the level of the pins *P*. The adjustment of the cam wheel *R* and the crank *C* with angular

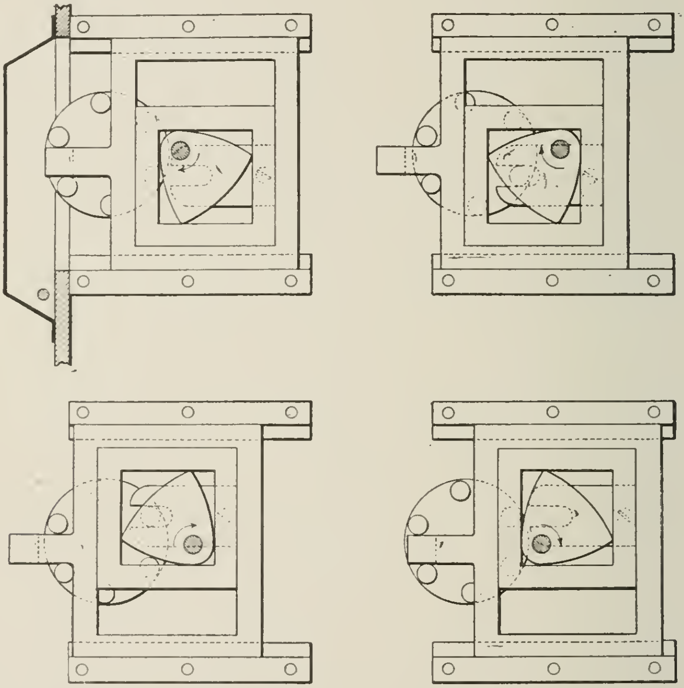


Fig. 21. Pin Intermittent Movement Taking the Four Movements from One Cam

relation to each other is such that the pins *C* are shoved into the holes of the film by the cam wheel *R* just as the pins come to rest at their upper limit of movement, and they are withdrawn just as they come to rest in their lower limit of movement. The time of motion of the film is, therefore, just one-half the total picture time, the film remaining at rest during the remaining half of the picture interval.

Another design of pin movement, suitable either for the direct action of the pin upon the film or for action of the pins upon a sprocket shaft for intermittent sprocket motion, is shown in Fig. 21, which illustrates the device in four of its positions of operation, and shows it equipped for driving a sprocket shaft intermittently. The sprocket shaft, or intermittent shaft, is shown with six pins, and the teeth of the intermittent driving movement are shown near the middle of each of the figures. The triangular cam is the steady drive member of the device, and it has such form that it fits the four sides of the square surrounding it at all times. In the upper left-hand drawing, the teeth are withdrawn from the pin of the intermittent wheel; in the upper right-hand drawing, the triangular cam has turned and has advanced the teeth to enclose one of the pins upon the intermittent wheel, which as yet has not been moved; in the lower left-hand drawing, the triangular cam has moved further and has lifted the teeth enclosing the pin of the intermittent wheel, thereby driving the intermittent wheel through one-sixth of its revolution; in the lower right-hand drawing the triangular cam has moved further and has withdrawn the pins from engagement with the pin of the intermittent wheel, and is in readiness to be lowered into the position shown in the upper left-hand drawing, to repeat the cycle.

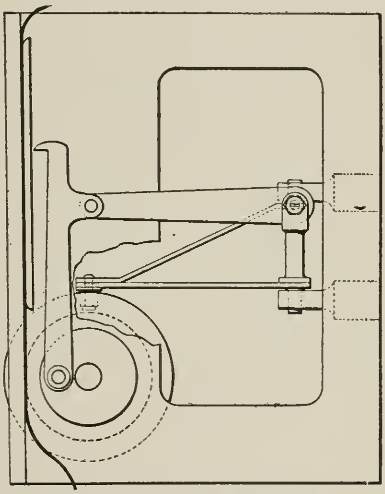


Fig. 22. Pin Intermittent Movement from Two Cams

Another type of pin movement is shown in Fig. 22, where the action is attained by two cams. The pin pair is located at the top of the vertical lever upon the wrist pin, which drives it vertically as a pitman rod, but at the same time the top of the vertical pin lever is rocked to the right and to the left, as viewed in the figure, by the arm which is attached to it near the pins at the top and which passes to the right. By means of this auxiliary cam connection, the pins are advanced into the film holes when the lever is at the upper limit of its stroke and are withdrawn when it is at the lower limit.

Still another type of pin movement acting directly into the film holes is shown in Fig. 23. The two cams are upon one shaft, one,

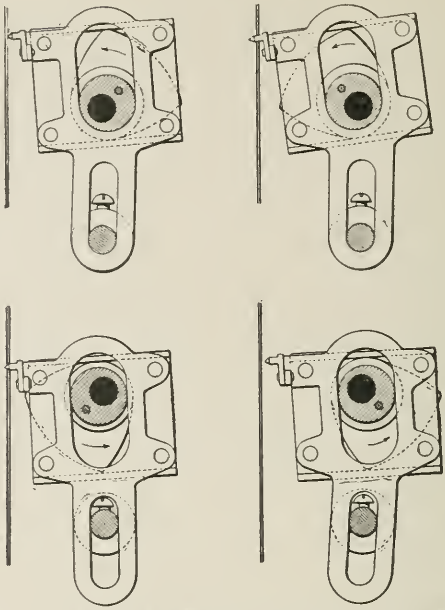


Fig. 23. Pin Intermittent Movement Taking the Four Movements from Two Cams on the Same Shaft

a triangular cam, providing for the vertical movement, and the other a circular cam, providing for the movement toward and from the plane of the film. These cams take the proper angle on the shaft to provide for inserting the pins into the film holes while the pins are at rest in their vertical movement.

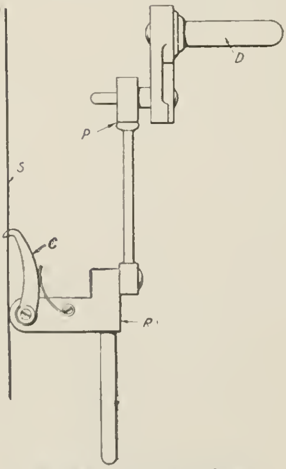


Fig. 24. An Intermittent Mechanism Built Upon the Claw Principle

Claw. The principle of the claw intermittent movement is shown in Fig. 24. In this figure, *S* is the film with perforated edges, preferably only one hole per picture; *D* is the steady drive shaft, *P* a pitman rod, *R* a reciprocating frame carrying the claw, and *C* the claw itself. The operation is merely that of a pawl upon a rack or ratchet, the film being the ratchet or rack and the holes being the spaces between the teeth for the claw or pawl to engage. As the pitman rod draws the reciprocating frame up, the claw rides on the edge of the hole until lifted out of the hole, then it rides upon the film under pressure of its spring until it reaches the next hole, when it drops in. When the pitman then drives the reciprocating frame down, the claw drags the film down, and again rides up to the next hole.

The pin and claw movements both are very severe in wear upon the holes of the film. They are suitable for cameras where the film is passed through the machine but once; frequently they are found on projecting machines of an older type.

Beater. The principle of the beater intermittent movement is that the film shall be taken up constantly, and at a constant rate,

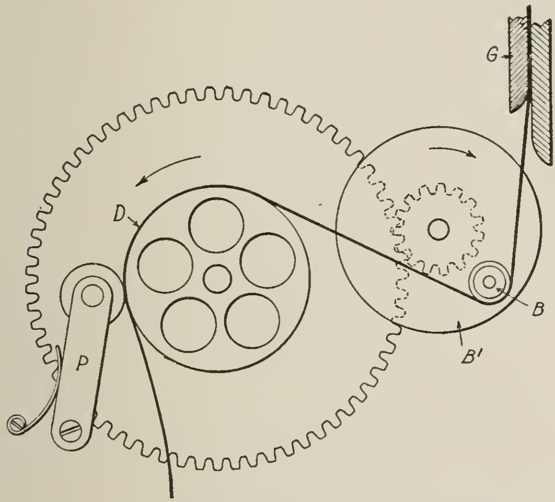


Fig. 25. An Intermittent Mechanism of the Beater Type

but that there shall be a definite amount of slack pulled through the film gate into a lower film loop just below the film gate, this slack being pulled through once for each picture interval, to shift the picture in the film window. The amount of slack in the film loop between the film gate and the steady drive take-up wheel shall be greater than the picture length of the film, so that the take-up wheel never pulls directly upon the film at the film gate but acts only to take up the slack pulled in by the beater. The beater may be a wrist pin upon a face plate, or it may be a spring-propelled or pitman propelled device, or any reciprocating part whatsoever.

Wrist-Pin Type. The wrist-pin type of beater intermittent movement is shown in Fig. 25. The steady drive wheel is shown as a drum at *D* with the presser roller *P*. The beater pin *B* is upon the face of the wheel *B′* and the wheels *B′* and *D* are geared together by a pair of spur gears. As the pin *B* passes over the top of its travel, the wheel or drum *D* takes up the slack between *D* and *G*, or takes up a definite measure of the slack, although perhaps not all of it. Then as pin *B* passes downward it pulls upon the film and draws through the film gate *G* just as much as has been taken up by the drum *D* since the last pull. The amount of film pulled through the film gate *G* does not depend upon the size, character, position, or radius of rotation of the beater pin *B*, but does depend upon the amount of rotation of the drum *D*, or the amount of lineal travel of the surface of the drum *D* for each revolution of the beater pin *B*.

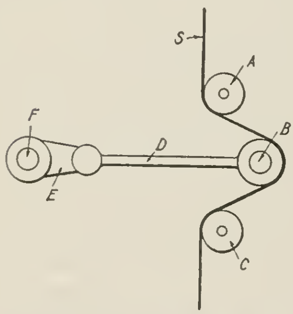


Fig. 26. The Pitman Type of Beater Intermittent Mechanism

Pitman Type. The pitman type of beater, illustrated in Fig. 26, shows the beater mechanism alone. The film *S* is shown as a heavy line from top to bottom of the figure, bent between the two fixed studs, *A* and *C*, which may be merely idler rollers, by the thrust of the beater roller *B*. The beater roller *B* is carried upon the pitman rod *D* which is driven by the crank *E* upon the steady drive shaft *F*. The film gate of the figure is assumed to be above the mechanism of the figure, and the steady drive take-up device is assumed to be below, taking up between shifts the slack pulled into the film by the beater roller *B*, or at least a part of that slack. In this device, as in all beater devices, the amount of film drawn into the film gate by the action of the beater roller is not dependent upon the characteristics of the beater roller or of the fixed studs co-operating with it, but depends solely upon the amount of film travel over the take-up drum during a single revolution of the steady drive shaft *F*.

Spring-Bar Type. The spring-bar beater is still another type of beater intermittent mechanism. It consists of a beater roller mounted upon a spring-pressed bar, which bar is restrained by a ratchet mechanism until the shift is desired, when it is released to strike the film so as to draw the slack into the film loop, being immediately picked up by its restraining mechanism again, and again held until the instant of the next shift.

Intermittent Grip. The intermittent grip mechanism, shown in Fig. 27, is in a class by itself, but never has come into general use. It operates without perforations in the film. The two wheels revolve toward each other, and when the enlarged places meet with the film between them, the film is gripped and drawn downward through the film gate. The amount of film pulled at each such meeting,

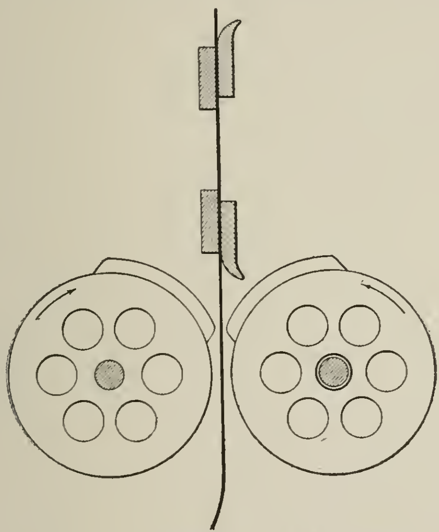


Fig. 27. Intermittent Grip Mechanism

that is, at each revolution of the pair of grip wheels, depends upon the length of the gripping surfaces which meet each other. Framing is accomplished by shifting the rollers slightly so that their ends overlap, the extending ends not being effective in pulling the film, and thus reducing the amount pulled.

For the greater part, all mention of intermittent mechanisms other than the intermittent sprocket feeds are historical, the sprocket being almost universal at the present time for projecting machines; many of the variations in intermittent mechanisms, and particularly in pin mechanisms, are found in cameras for taking motion pictures.

Adjustment of Intermittent Movements. The customary adjustment provided for the intermittent movements for taking up wear between the wheels or cams is the eccentric bushing. This bushing, which is included as a part *D* of Fig. 9, is placed in the hole in the frame through which the drive shaft of the intermittent movement passes, and the drive shaft itself passes through the hole in the bushing, indicated by the small dotted circle. By turning the bushing slightly in the frame, the position of the drive shaft is changed very slightly as compared with the movement of the bushing, and a very accurate adjustment is possible. The cams should be adjusted when properly oiled with a medium heavy oil—a very light oil will not stay on the cams and a very heavy oil is too sticky for the rapid cam motion. If adjusted dry, there will not be room for the oil to work between the cam surfaces without making the adjustment too tight, and if adjusted with a surplus of oil the oil will work away and leave them loose. The adjustment of the cam band of the pin wheel and the concave wing of the star wheel must be very accurate or the picture will lose its steadiness on the screen, taking a slight vertical jiggle. Many Geneva movements are fitted with an oil box or tank and run immersed in oil.

The pin and claw movements must be kept carefully adjusted, particularly as to those cams which give the film the vertical movement. The film teeth of these mechanisms wear rapidly and should be examined frequently and replaced when wear is detected.

In the beater type of mechanism, the beater roller usually is cut away in the middle and strikes the film only on the edges, outside of the picture space. With rollers thus cut away in the middle, the remaining bosses which strike the film are likely to become worn conical, tapering toward the inside, resulting in irregular action of the film and consequent jiggling on the screen. In addition, a worn beater roller wears the film by bending it.

The edges of the celluloid film in the holes engaged by the sprocket teeth or pins or claws are sharp and hard enough to cut away the teeth which grip them and particularly because of the rapidity and of the almost innumerable times that the film is gripped, pulled, and loosened in the course of a few months' use of a projecting machine in a theater. Wear of the teeth engaging the film acts upon the film, for the teeth wear into a hollow on the pulling face, making the point of the tooth of slightly hooked shape, and these hook teeth pull against the edge of the holes and tend to tear the film as they leave it. Worn teeth must be watched for and replaced when noticed.

Sprocket wheels are interchangeable, and new ones can be bought from the projection machine makers and placed on the motion head with little trouble, or new rings of teeth can be bought and placed upon the old sprocket drums or bosses. Some types of sprockets are especially constructed with interchangeable teeth, and new tooth rings may be bought at a very low price to replace the worn ones.

In addition to watching for wear and loose adjustments, the moving mechanism of the intermittent and all other parts of the motion head should be cleaned periodically, say, every two months if the machine is running evenings only and is giving no trouble, and every two weeks or every month if the machine is running all day, even though giving perfect service, and with no indication of trouble. Wipe off all oil, and empty the oil bath of the intermittent movement if it has one. Run the intermittent tank full of gasoline and turn the machine for a while to work it thoroughly through the cams; of course it will work out through the journals of the oil box and wash those clean. Wipe it off as it comes out, using a clean rag. Next, the mechanism should be oiled liberally with a very light oil to wash out the residue of the evaporated gasoline, and this light oil then should be followed with the standard body of oil regularly used on the machine. The gasoline (or even kerosene) loosens the dirt, the light oil carries out what the gasoline left by its too rapid evaporation, and the journals then are clean and ready for their standard working dose of regular lubrication. Do the same for all of the journals, putting oil in the oil holes with a can spout and wiping it off as it runs through—first gasoline, then very thin oil, then regular lubricator—loosen the dirt, wash it out, then oil up for service. The toothed surfaces of the gear wheels should be cleaned in the same way, for they pick up grit very freely. If after cleaning the gear wheels they rattle a little, wipe them as dry as possible and hold a lump of beeswax against the teeth and turn the handle of the motion head through several revolutions. This will quiet the noise without injuring the gears.

CONTINUOUS PROJECTION

Any system which will keep the illumination constant upon the screen will be independent of the disadvantages of flicker, and possibly other disadvantages may be avoided or disadvantages obtained by devices designed to project the second picture upon the screen before the first is removed, as with the dissolving lantern.

Four methods of attack, none of which has come into general use, have been used for this problem, viz, duplex projection, moving lenses, moving mirrors, and moving prisms.

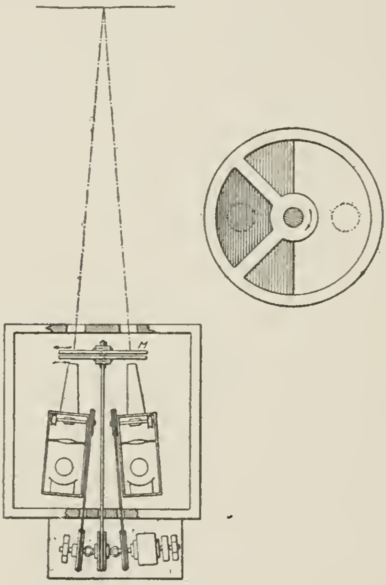


Fig. 28. Duplex Projection

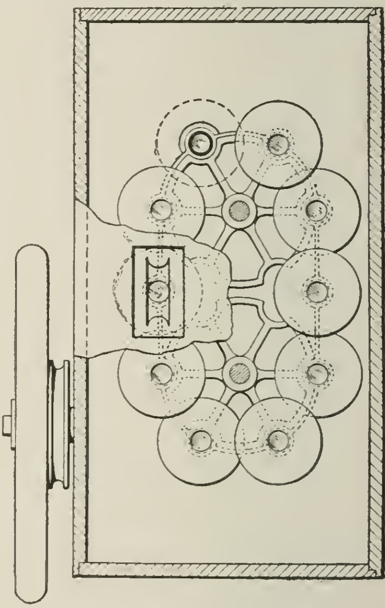


Fig. 29. Continuous Projection by Moving Lenses

Duplex Projection. Duplex projection consists of projecting from two lanterns with a dissolving shutter, each change dissolving from the old picture to the new, and each lantern shifting its film to the succeeding picture while the viewing screen is under full illumination from the companion lantern.

The arrangement of the two lanterns driven by one motor is shown in Fig. 28, the lanterns indicating by the dotted lines that the central rays projected reach the same point upon the picture screen. At the right of the lantern diagram is seen the front view of the before-the-lens shutter M which is placed between the two lanterns and acts as shutter for both of them. The white half is the open half, the dark quarter is opaque, and the remaining portions are semi-transparent. These semi-transparent portions of the shutter extend the dissolving of the view and make it a little softer than a simple half-and-half shutter would give.

Moving Lenses. Moving lenses for continuous projection are shown in Fig. 29, which is a front view of the projecting machine. The lenses of the chain are spaced $\frac{3}{4}$ inch apart—just picture distance—and each of them follows a picture down as the film passes

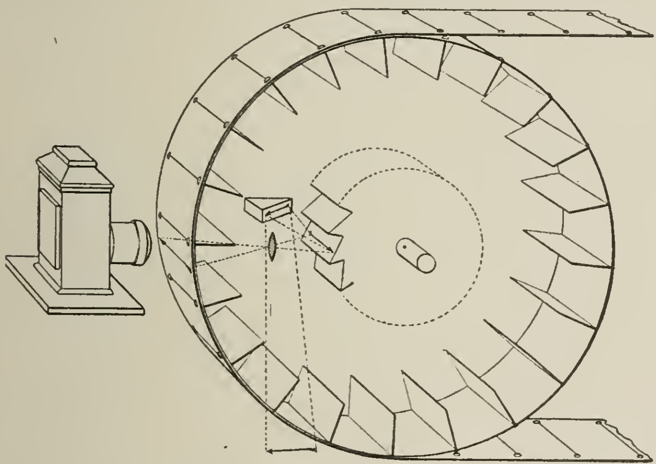


Fig. 30. Continuous Projection by Moving Mirrors

with steady motion through the film window, which is nearly as long as two pictures. There is no intermittent mechanism in this projector. The middle lens at the left of the chain is shown in the middle of the projection window, and as the lens now visible through that window passes downward with its film image, the next lens will approach the projecting window from the top. The top and bottom edges of the projecting windows are substantially shutter edges, and as the following lens comes into action at the top of the window, the preceding lens will go out of action by passing behind the lower edge of the window. Thus, a dissolving effect is secured, and continuous illumination of the screen is effected, changing the images without intermittent mechanical motion.

Moving Mirrors. Moving mirrors for continuous projection are shown in diagrammatic perspective in Fig. 30. The large wheel is a wheel of shutter leaves, carrying the picture film upon its surface, or upon the edges of the shutter leaves which form a series of windows over which the pictures of the film are stretched. In the center of the wheel is a drum of mirrors which is arranged to turn at half the speed of the drum of shutters carrying the film strip and pictures. At the left is the lamp house and the dotted lines show the course of the beam of light

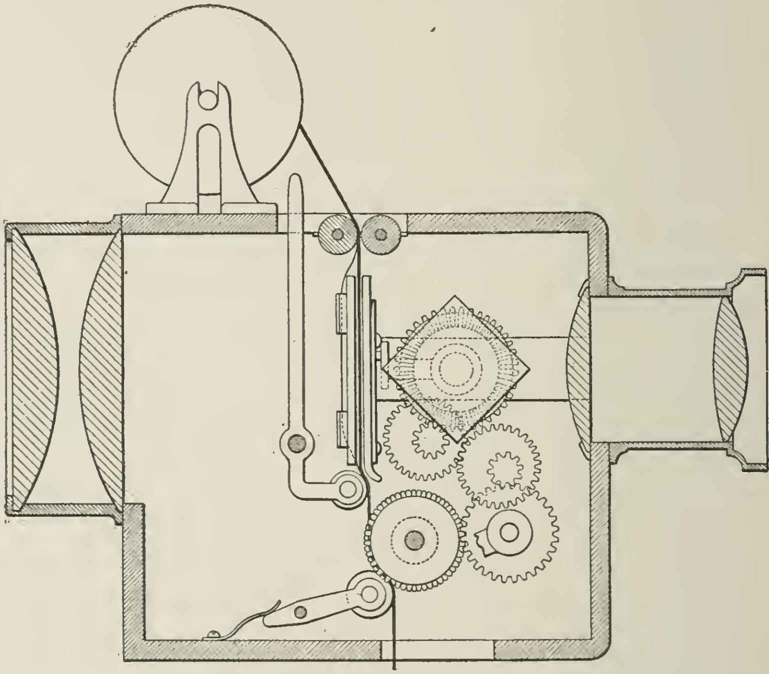


Fig. 31. Projecting Machine for Continuous Projection by Moving Prism

from the lamp house through the condensers in the front of the house, through the film, through the single lens to the drum of mirrors, then to a fixed mirror and then downward, whence the beam carries to the picture screen. Again there is a continuous illumination of the screen without any intermittent mechanism. Two mirrors of the drum in the center always will be working in the beam of light between the lamp house and the screen, one mirror projecting the upper and the other the lower portion of the picture seen upon the screen, except at the instant when one mirror ceases and another begins the projection.

Moving Prisms. Moving prisms for continuous projection are shown in Figs. 31 and 32. Fig. 31 shows the diagram of the complete projecting machine from condensers to objective lens, and Fig. 32 shows two diagrams disclosing the course of the rays forming the beam of light through the film, prism, and objective lens. No intermittent mechanism is used.

Steady Feed Elements. The motion head projecting by intermittent motion of the film is provided with two elements of steady feed for relieving the film from the jerk of the intermittent as far as possible. If the intermittent feed were required to pull the film from the feed reel, turning the reel in so doing, and if also the take-up reel were allowed to pull directly upon the teeth of the intermittent sprocket, the wear upon the film and upon the sprocket would be

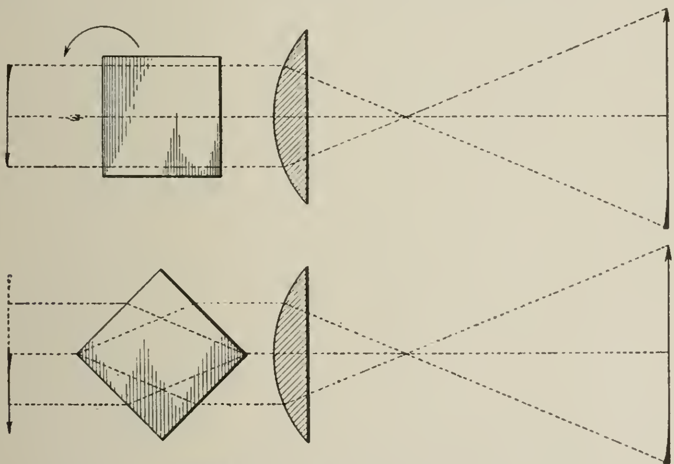


Fig. 32. Diagrams of Course of Light Rays in Continuous Projection by Means of Moving Prism

great. This is much reduced by providing upper and lower steady feed sprockets, relieving the intermittent mechanism from all duty but the shift of the short piece of film in the film gate, the film being brought from the feed reel down to the upper end of the film gate by the upper steady feed sprocket, and being held slack below the intermittent and fed to the take-up reel under proper tension by the lower steady sprocket. In order that a proper looseness of film, or slack to avoid strains, may be had above and below the intermittent feed, the film is formed into slack bends which are known as *upper feed loops* and *lower feed loops*.

THREADING UP THE MOTION HEAD

The course of the film through the motion head, the elements which operate upon it, and the method of placing the film in position may be studied at the same time, taking the steps in the order in which they are encountered by the film in its travel.

Feed Reel. The feed reel is a spool upon which the picture film strip is wound when ready for projection. It consists of a core from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in diameter, with a spring clip for taking the end of the film which is to be the inside end of the reel; the reel then is turned and the film is wound upon it, a strip of 1,000 feet of film filling the reel to a total diameter of about 10 inches. The 10-inch reel has upon its core two sheet-metal flanges equivalent to spool ends, which are about 10 inches in diameter. Winding the spool full of the film to be projected, beginning with the "end of the picture" or "tail" of the film, and finishing with the "title" of the picture or "leader" of the film upon the outside of the spool, is called *rewinding*, and when so wound, or rewound it is ready to be placed in position.

Feed-Reel Magazine. An iron fireproof box with a fire-trap film outlet is provided for receiving the feed reel. The feed reel, in response to the pull upon the film by the upper steady feed, turns loosely in this fireproof magazine. Place the full feed reel in the upper magazine, start the lead end of the film through the film outlet at the bottom of the feed magazine, just above the motion head, and close and fasten the feed magazine door. The feed reel is shown without its fireproof magazine at *1* in Fig. 33.

Upper Steady Feed. The lead end of the film is pulled out about 3 feet, the presser roller is lifted from the upper steady feed sprocket and the film is laid upon the surface of the sprocket drum with the teeth of the sprocket passing properly through the holes in both edges of the film. The presser roller is dropped upon the drum with its spring, or there may be two such presser rollers, or an idler roller between the upper feed and the feed reel. In Fig. 14, an idler roller is shown at *2* to direct the film to the upper steady feed sprocket *3* at the top of the sprocket so that the film will wrap a full half-way around the sprocket and get the benefit of a pull by a large number of the sprocket teeth. The presser roller—or friction roller as it is sometimes called, though friction is no part of its function—is shown by the small circles just below the sprocket *3*, not numbered.

[illegible] KILLED BY HIS OWN KNIFE

THE YOUNG SAILOR PUTS FATHER TO WORK
Scene from Photoplay, "Taming a Tyrant"
Courtesy of *Essanay Film Mfg. Co., Chicago*

Upper Feed Loop. The film is formed into the upper feed loop before passing to the film gate, that is, the film gate is opened and the film is placed in the groove of the body of the gate, the film being lifted from 2 to 6 inches higher in the gate than it would be if stretched straight from the top steady feed sprocket to the gate. The film in the gate is carried into engagement with the intermittent sprocket teeth, and the door of the film gate is closed upon it, clamping it in position. The placing of the film higher in the film gate leaves a looseness in the film above the film gate and between the film gate and the upper steady feed sprocket, which forms the upper feed loop, as shown at *4* in Fig. 33. At every shift, the intermittent feed pulls some of the slack out of this loop, and between shifts the upper steady feed feeds the film down to replenish the slack pulled out by the intermittent.

Film Steady Drum. In some motion heads the film is not permitted to feed directly from the upper feed loop to the film gate, but is taken over a drum which guides it into the entrance to the gate. This film steadier is shown at *5* in Fig. 33, and its presser roller is shown by the small circles just above the drum *5*.

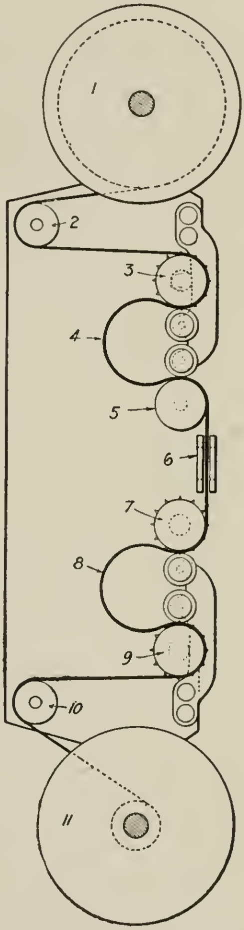


Fig. 33. Diagram Showing Film-Feeding Elements of the Motion Head

Film Gate. The film gate is indicated at *6* in Fig. 33. It is of many types, but usually has a door to be opened, and a groove into which the film is laid and upon which the door is then closed.

Intermittent Sprocket. The teeth of the intermittent sprocket or of the intermittent feed of any type usually are so closely associated with the film gate that they substantially run in the sides of the groove through the body of the film gate, so that at one operation the film strip is placed in the groove of the gate and upon the teeth of the intermittent mechanism. The intermittent sprocket is shown at *7* in Fig. 33, and its presser roller is shown by the small circles just below it.

Lower Feed Loop. The lower loop is formed as the upper loop was, by placing the film upon the lower steady feed sprocket from 2 to 6 inches higher than it would lie if drawn straight from the intermittent mechanism or film gate. The lower feed loop is shown at *8* in Fig. 33. The intermittent pulls three-quarters of an inch of film into this lower loop at every shift of the pictures, thereby increasing the size of the loop, but the lower steady-feed sprocket takes the film up steadily and takes up the exact amount of film before the next shift.

Lower Steady-Feed Sprocket. This sprocket is shown at *9* in Fig. 33, and its presser roller is shown by the small circles just above it. In this figure the presser rollers of the upper steady sprocket and of the friction drum are placed upon the same arm, while the presser rollers of the lower steady sprocket and of the intermittent sprocket also are upon the same arm—this is a matter of preference and convenience for the operator as differently designed by the different manufacturers. The film now is taken over the idler *10* —which is omitted in some motion heads—to the take-up reel.

Take-Up Reel. This is substantially the same as the feed reel. If the end of film leader which was drawn out of the feed magazine to begin threading is not long enough to reach the take-up reel, the handle of the motion head may be given a few turns, feeding the film down. The end is passed into the take-up magazine through the film outlet (which is an inlet this time) and the end is fastened under the spring clip upon the hub of the take-up reel. The slack of the film between the take-up reel and the lower steady feed is wound up by turning the spool itself by hand, then the motion-head handle is given a turn or two with the take-up magazine door open in order to make sure that the take-up is working properly. Then the door of the take-up magazine is closed and you are ready to light up, start the crank, open the fire shutter, and "let 'er flicker"—for slang ceases to be slang when it is simple truth.

The take-up must be watched particularly at the beginning of the film reel, and particularly toward the end of the film reel, when the take-up reel is nearly full, is heavy to move, and moves slowly on account of the long distance around it. The take-up reel moves more and more slowly as the spool gets more and more nearly full, and some compensation is required between the speed of the reel, always varying, and the speed of the driving handle, which is constant. This compensation usually is provided by a friction drive for the take-up reel—perhaps, a pair of friction plates held together by a spring; perhaps, two grooved wheels belted by a belt which is supposed to pull tight enough to pull the heaviest load and yet slip rather than tear the film or stop the operator's arm. These friction devices should be noted and kept in proper adjustment, for a friction device can hardly be expected to stay in adjustment very long, as the plates wear smooth or get grit between them, and the belts stretch. The friction device must drive the take-up reel fast enough to take up the film on its small center when the film is just starting, and must not pull so hard that it will pull the film apart in its weaker spots. Excess friction makes the handle turn harder.

Framing Devices. The word "frame" when applied to the projection of motion pictures refers to the position of the projected image upon the picture screen, or to the position of the film image as related to the film windows. When the top of the picture is at the top of the screen, or at the bottom of the film window, and the picture just fills the screen and the window, the picture is said to be "in frame," the image fitting the film window as the lithograph fits the frame on the cottage wall. When, by reason always of improper adjustment of the film or of the motion head, the top of the picture on the screen is a few inches from the top of the illuminated area upon the screen, and the lower edge of the next picture shows across the top of the picture being projected, then the picture is said to be "out of frame," and when examined in the film window it will be seen that the little image does not register with the window. As films may be defective in median portions, the motion head must be able to frame while running.

Framing is accomplished by shifting the film with reference to the lens or film window. Somewhere about the motion head—and its position and general appearance varies with different makes of machines—will be found a *framing lever.* When the motion head is standing at rest, and when the framing lever is moved, (*1*) the lens and film window will move upward or downward with the film remaining stationary in the gate; or (*2*) the film gate and intermittent mechanism as a whole will move upward or downward, the lens remaining stationary; or (*3*) the intermittent feed alone will move as a whole and will draw the film downward or try to push it upward through the film gate; or (*4*) the intermittent sprocket will rotate a little in one direction or the other, without changing the location of its shaft; or (*5*) a little slack will be taken up or let out in a *framing loop* formed for the purpose of framing, and located between the intermittent feed mechanism and the film window.

Framing is usually and most easily accomplished by looking at the picture projected upon the screen. The picture may be brought approximately to frame by looking at the film window after threading up the head and before beginning projection. The final adjustments, like the final adjustments of focus, should be made by watching the picture screen during projection.

The framing lever always has a movement of more than one full picture. When you try to "frame up" and the lever will not move far enough to frame the picture, then "frame down" nearly a whole picture instead and the proper adjustment can be reached.

Rewinding. When the reel of film has been turned through, the tail end is allowed to run through to the lower steady feed, then is caught and taken back to the feed reel. The main drive handle may have a shift to throw it to a rewind position, or it may have to be removed from the main drive shaft and placed upon the end of a special rewind shaft; in either case, the turning of the handle when changed for rewinding will turn the feed reel rapidly and will wind the film back from the take-up to the feed reel and at a much faster speed than the speed of projection—one to two minutes to rewind a reel which took twenty minutes to project.

The laws of New York and possibly of some other states do not permit the rewinding of film in the projecting room. It must be taken from the projecting machine in the reel and rewound to a feed reel. Two reels mounted edge to edge, near each other, with a crank and gear on one of them, is the rewinding device then used.

Automatic Rewind. Devices for avoiding the rewinding of the film before a second projection have been suggested and tried. Fig. 34 shows a well-known projector equipped with the automatic rewind, or rather with such a relation of take-up and feed devices that no rewind of any kind is required. The feed magazine feeds *from the middle of the roll of film* and the take-up reel rolls the film up with a large center hole, so that the operator may take the roll of film from the take-up magazine, drop it into the feed magazine, start the inner end through the film outlet and thread it through his motion head back to the take-up, and his machine is ready for another projection of the film. Not only does this sort of improvement save the operator's time and labor, but it saves wear on the film, which becomes scratched in rewinding at high speed.

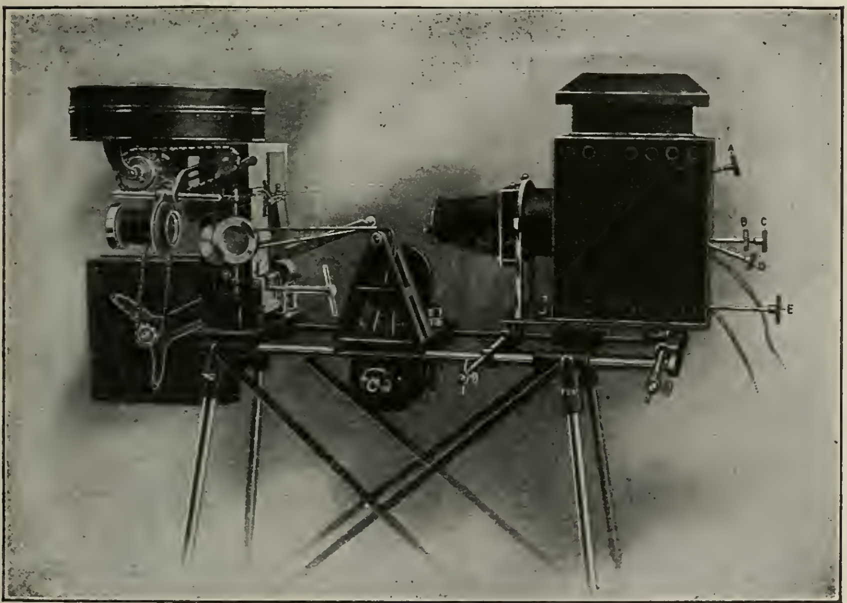


Fig. 34. Projector with Automatic Rewind

Another type of machines joins the leader to the tail of the reel and runs the picture twice or more without stopping, if desired.

No automatic rewinds are in general use in theaters as yet, though the type illustrated in Fig. 34 was widely sold at one time, and the endless belt type is used in penny arcades.

Film Basket, or Molasses Can. The take-up reel goes wrong in operation oftener than any other one part of a projector. Often the operator must stop the show to set it right, and in the middle of a picture reel. A more reliable method is to let the film run from the lower steady feed into a sheet-iron can or box of 2 or 3 cubic feet, folding up loosely as it runs in. It is rewound from this can to the feed reel. Because of the early practice of letting the film run into an open basket, with its comparatively great fire risk, this take-up can is still called a "film basket" by older operators, while it is called a "molasses can" also from the manner in which the film folds down into it. Where the fire ordinances of the town permit it, the can will be found to "give a better show" than the take-up reel; it is less wearing on the operator and on the film.

Operator's Control of the Picture. There are two features in which the operator has control directly for modifying the picture—*speed of projection* and *brightness of light on the screen.* Framing is not a matter of arbitrary control, it is merely a necessary detail which must be kept in adjustment.

The picture may be improved by reducing flicker when possible by reducing the illumination, either by a lamp adjustment if convenient, or by a tinter; preferably the tinter, since by removing the tinter the full illumination is restored immediately when a dense scene is projected in the run of the same reel.

Flicker may be reduced by speeding up the rate of turning, also. In the case of a picture having the upper part of the screen white sky and the lower part dark foreground, the illumination must be retained to make the foreground visible, and the only means for reducing the flicker is speed.

The sentiment of the picture may be watched and speed may be used accordingly, the operator turning more rapidly where he deems the action of the picture could be improved thereby. The manufacturer should have timed his action when making the picture, but sometimes this is neglected.

Motor versus Crank. Most cities prohibit the motor for turning the motion head. The way to keep the operator attending closely to his film is to keep him at the machine turning the crank, hence all other methods of driving the motion head are forbidden. Where the motor is permitted, a small electric motor of the usual fan size, $\frac{1}{12}$ or $\frac{1}{16}$ horse-power, will drive it. In case the motor is used, the film always should be started and turned for 50 feet or more with the crank before the motor is switched on. This gives the operator the "feel" of the machine and tells him whether everything is running as it should. Then the labor is turned over to the motor for the greater part of the run of the reel. Just before the end of the reel the operator should take his crank again and shut off his power, again assuring himself by half a minute of hand turning that his projector is in perfect running order and does not require repairs or readjustment before starting the next reel. The operator's hand upon the crank is the doctor's finger on the pulse of the patient; the slightest irregularities in mechanical action are noted by the "feel" of the handle. The operator's eye must be upon the screen practically all of the time for framing and focus, even if not for flicker.

FILM

Films of all makers for general commercial use are made to about the same size, $1\frac{3}{8}$ inches wide, $\frac{1}{200}$ inch thick including celluloid and gelatine; of this width of $1\frac{3}{8}$ inches, a strip down the middle 1 inch wide is reserved for the picture and the holes are punched in the margins near this strip, $\frac{3}{16}$ of an inch apart. The various makers follow this standard rather loosely, because it is itself rather loosely composed and rather indefinitely expressed. One of the most prominent points of variation is the shape of the hole used; another is the distance between the two rows of holes, or the distance from either edge to the nearest row of holes. A movement is being made to work out a standard, expressed accurately in thousandths and split thousandths of an inch. It is believed that the life of films will be lengthened if all are alike and the projector may then be built accurately to that film size.

Care of Film in Projecting. Fit the film accurately to the sprockets before starting projection. If possible, look through the reel for bad edges, bad splices, or unframed splices before beginning projection, and repair any troubles found. Listen to the purr of the film over the steady feed sprockets and bad places in the sprocket holes will be detected when running. Watch the screen for unframed splices and for focus; a film which runs out of focus for a few seconds at a time and then runs true, constantly varying the focus while the lens and film are unmoved and the film gate is clean and perfect, may be warped; it should be moistened, as discussed under the subject of warped films. If a film rattles as it leaves any of the sprockets, the teeth of the sprocket may be worn into hooks; a new sprocket is the proper remedy.

Care of Film in Rewinding. Rewind under steady tension. Do not rewind loose and then holding the film take up the slack by winding the center of the coil tighter; that grinds into the film any grains of dust which may have been collected and which otherwise might be brushed off. In rewinding, the film may pass over a soft rag, or through a soft rag held bunched in the hand, to wipe off the dust, the first time it is rewound. Particular care must be given to the gelatine side of the film in order to avoid scratching.

Care of Film in Storage. The film should always be packed in metal cans or flat boxes when setting it away. It must not be kept in a warm place as the celluloid will give off explosive gases, the gelatine will dry out and warp the film, and the celluloid will shrink with the heat, particularly if it be an NI (non-inflammable) film.

Care in Handling Film. Do not let the ends of the film become unrolled; they are liable to a sharp bend which leaves a crease and ultimately a break. Keep the roll flat when off the reel. The dropping out of the middle in a cone shape and pushing back again only adds scratches where none are needed. Handle by grasping the flat of the reel which is the edge of the film, and handle as little as possible.

Packing for Shipment. Place the film first in the iron box, then in the wood box, and see that the danger label which the film exchange puts on is still on the outside of the box. In unpacking, see whether the box is fastened with screws, if so use a screwdriver, not a hatchet; and use the same box for re-shipment to the film exchange.

Repair of Films. The usual method of repairing films is to cut out the defective place and splice the ends together, thus reducing the length of the film by the few small pictures cut out with the bad place. Where a crack is seen starting across the film, it is easier to take a piece of clear celluloid film strip from which the gelatine has been soaked and cement ½ inch of it across the film over the crack, than it is to splice it. This is cemented upon the glossy side, leaving the gelatine and the picture image intact, and it saves the order of pictures in the film without causing a sudden jump of the moving characters when the fault is reached in projection. The film thus repaired is no thicker than a splice, and will pass the sprockets and film gate with the same ease. The patch should not be more than one-half a picture in size, or the film will be stiffened more than a splice would stiffen it.

Where the sprocket holes have a bad spot, a piece of blank film (with the gelatine soaked off) may be attached sometimes to avoid cutting out good images.

Film Splicing. Cut one end on the line between pictures; cut the other end with a quarter picture on; thus in cutting a film there will be three-quarters of a picture cut out, a picture and three-quarters, etc. Moisten the gelatine on the quarter picture and scrape it clean:

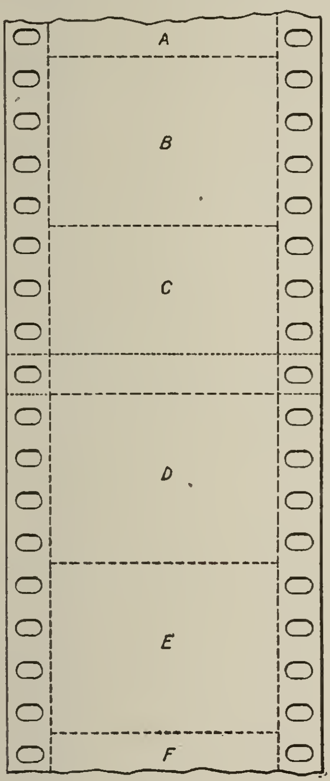


Fig. 35. A Splice "In Frame"

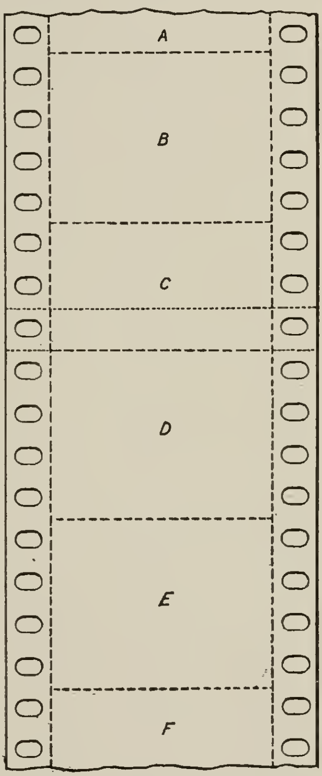


Fig. 36. A Splice "Out of Frame"

also scrape the celluloid side of the other end clean. Spread cement on the cleaned quarter picture space and put it on the back of the other end, sticking the two ends together with the picture lines matching and with the sprocket holes matching. Cut either through a sprocket hole or midway between sprocket holes, straight across the film. Small scissors are more convenient than a knife.

Splicing by Machines. A number of forms of splicing machines are offered. All of them have teeth for registering the sprocket holes while the splice is setting, and all of them require special instruction and some skill of hand and common sense. Either with or without the machine, get some scraps and practice on them until you can make it right. Your film exchange or a friend operator will give you a handful of short pieces for practice; and the cement is twenty-five cents for a very small bottle. A flat stick is the best cement spreader.

Non-Inflammable Film. In splicing a non-inflammable film a special cement is required, the NI film cement being suitable for either ordinary film or NI film.

Splicing "in Frame." Splicing a film "in frame" may be understood by a study of the companion figures, Fig. 35, which shows a splice "in frame" and Fig. 36 which shows a splice "out of frame."

In Fig. 35, the picture *C* has four holes at the side, just as have the pictures *A*, *B*, *D*, *E*, etc., and when that film is passed through the film gate and intermittent mechanism, the "framing" will be preserved, because mechanically the film is the same in distribution of pictures and of sprocket holes as though no splice had been made. The difference is found in the "jump" of the pictures where a picture or more have been omitted, but the "frame" will not be disturbed as the splice passes.

In Fig. 36, the picture *C* has but three holes at the side. The result is that when the picture *B* is pulled out of the film window and the picture *C* is pulled in, the intermittent mechanism pulling down four holes will pull into the film window the three-quarter picture *C* and also the top quarter of the whole picture *D*. Again, upon the next operation of the shift mechanism, the intermittent feed pulls down four holes, the picture *C* will be pulled down, and there will be pulled into the film window the remaining three-quarters of *D* and the top quarter of *E*. This will continue, showing the lower three-quarters of one picture and the upper quarter of another, until the operator notices the screen and frames with his lever. This is called a splice "out of frame," because the splice throws the picture out of frame in passing.

Framing by Splicing. Every time a splice "out of frame" is passed, the operator must "frame" with his lever until he can find opportunity to stop in rewinding and cut the faulty splice. Then he may splice it correctly "in frame" and thus put his reel of film in frame at that place when running.

Titles. Titles should be given the same care as the picture scenes of the film. The main title, forming the head of the picture film, should be given the favor of a very long leader if the title itself has been shortened, so that there will be ample leader to thread through to the take-up reel, to turn a few pictures to test the working of the take-up before closing the take-up magazine door, and further to turn a few pictures and get the motion head under speed before opening the fire shutter. Thus, the audience will get the full benefit of whatever title there is.

Leaders and Tails. The purpose of the leader and tail is to give the audience the benefit of all of the picture which lies between. The leader is a piece of blank film or a piece of scrap film, just so it has good sprocket holes, cemented to the title end of the reel, and of sufficient length to thread through the motion head and test the mechanism before bringing the title into the film window. The tail is a similar piece cemented to the end of the picture. Its purpose is to enable the operator to run the full picture on the screen before closing the fire shutter, then to stop his motion head before the tail has run into the take-up magazine where it cannot be reached conveniently for rewinding. Some motion heads are so constructed for rewinding that if sufficient lengths of leader and tail are provided neither end of the film need be detached from either reel if but one reel is to be run repeatedly in the projector. Stopping the motion head before the tail has been drawn from the spring clip of the feed reel, the film is rewound and the rewinding stopped before the leader is drawn from the spring clip of the take-up reel; the motion head then is threaded and the film is ready to repeat.

Blank *black* film may be bought from the film exchange for leaders and tails if the reels come too short for the operator's convenience.

Dry Film. The gelatine of the motion picture strip is charged with glycerine by the manufacturer in order to keep it elastic and to make the film pliable in handling and projecting. As the glycerine and the water which is held in the gelatine gradually dries out, owing to winding and rewinding through the air and the heat of the arc lamp, the film strip becomes dry and brittle, with a tendency to crack the gelatine film, which then tends to scale off from the celluloid.

Films may be moistened and their pliability restored by leaving them unrolled over a little water, not permitting the water to touch the film. Take a bucket holding four or six gallons, cut a false bottom of heavy wire mesh or perforated metal with legs or downturned edges to hold it 1 inch from the bottom of the bucket. Pour in $\frac{1}{4}$ inch of water, set the false bottom in, and run in a reel of film, letting it fold around as film does in a basket from the projecting machine. Cover the bucket for half an hour. When the film is reeled up it will be found much more pliable.

Warped Film. With the film in a close roll, the drying from the edges goes on more rapidly than from the central portions of the strip. This warps the film, making it take a curved section crosswise of the film when it should lie flat; and it takes the curve sometimes in the film window, putting the picture out of focus on the screen. Such a film may be treated with the vapor bath as described above, or it may be treated more simply by cutting two disks of thick felt the size of the end of the reel, dampening them, putting one on each side of the reel, wrapping it and letting it lie over night. Discretion must be used to avoid getting the felt or blotting paper too wet.

OPERATOR'S DUTIES

Before the Show Begins. The operator usually is held responsible for delivery to the theater of the film for projection. If in a city where the film exchange is visited, the operator makes the visit, returning the old reel and bringing the new to the theater. If in a town distant from the exchange, he is responsible for the packing and shipment of the old reel and the receipt of the new one and its delivery from the express office to the theater. Such deliveries may be daily, or only once a week.

Being thus the messenger to the film exchange to obtain the picture film, he is also made responsible for getting the song slides, and not only the slides but the sheet music for the singer which is supposed to accompany the song slides but sometimes does not except after a special effort to get it. If title posters are used, the operator is held responsible for their delivery also, as being something substantially a part of the film reel. Being thus in charge of the signs for the theater front, it is good if he can improvise signs with a brush and a sheet of paper when occasion requires, or when the title poster for a particular reel of film cannot be obtained as usual.

The operator is responsible for keeping up the necessary supply stock for the operating room—carbons, oil, and condensers for the lantern; film scrap and film cement for repairing films; cover glasses and binding strip for repairing slides. Whether he purchases the supplies himself or asks the manager to purchase them is immaterial. If the supplies run short, he will get the blame, hence the burden lies on him to buy or keep kicking.

Preparing for Projection. On going into his iron-bound cage to prepare for the projection of films and lantern slides for the afternoon or evening, the operator should turn the motion head at a good fast rate for the "feel" of the machinery; then clean the film gate, notice the gate and tension plate and sprocket teeth or intermittent pins for wear; then oil up ready for the run; clean the lamp, dusting out the carbon dust which collects in the bottom of the lamp house from the sparks thrown off from the arc; examine the lamp and connections to see whether any wires are burning weak from the heat of the arc, and whether any joints are loose; dust the table top, and lastly sweep off the lens surfaces with the camel's hair brush; inspect the carbon stock, and if insufficient for the day it may be necessary to omit the dissolving lantern or to set the rheostat to a lower notch to save carbon; inspect the new reel of film, if time is had, strengthening any weak spot found and framing up the reel by resplicing "in frame" any splices found "out of frame"; trim the lamp with carbons of sufficient length for the first reel, light up, center and focus the light, put in a slide to be sure that the stereo lens is still in focus; then put a piece of scratched mica (not celluloid) in the film gate for the test of the motion head lens for focus. He now is ready to begin projection.

Conducting the Program. The duties of the operator after the projection begins were discussed in an article which appeared in the *Nickelodeon* and which seems to cover the subject. It reveals the fact that the operator has duties other than turning the crank, and that training in actual service beyond the mere mastering of the mechanism of some particular projecting machine is an essential to the person who would become an efficient operator and valuable theater employe:

Every nickelodeon has its *stage manager*, whether it knows it or not.

There must be of necessity among the attendants of a motion picture theater some one who decides when the pictures shall start, when the song shall be sung, and how long the intermissions between the performances shall be. This person is the one who really is in charge of the program of the theater, and upon him depends to some extent both the pleasure of the patrons and the profits of the owner.

In a small theater, running to one reel of film only, without songs or specialties of any kind, the total manual duty connected with this duty of controlling the program is the turning off of the lights in the room when the pictures start, and turning them on again when the performance is finished. This requires merely a switch in the operator's booth, convenient to his hand, for the house lighting system.

In such an instance, the operator rewinds the reel of his film and adjusts the carbons of his lamp. He is ready to start the next performance. At this point, it is within his discretion to start the performance immediately, to delay it according to a time schedule, or to delay it as long as he thinks the audience will endure the wait without impatience. It can be seen plainly that the pleasure of the patrons and the profits of the owner lie within control of the person who is in charge of the program.

As the theater acquires additional features of entertainment the duties of controlling the program become more and more complex.

By adding an illustrated song, the operation of the projecting machine becomes more complex. In addition, the operator must have a push button to call the singer at the proper time to be in readiness when the song slides come upon the screen. If an automatic piano or phonograph is running as a *barker* in front of the theater and is making so much noise as to interfere with the enjoyment of the song (it may be noted that patrons sitting in the rear of the room will be much nearer to the automatic *barker* than to the singer), then the automatic barker must be stopped during the song, requiring another switch to be controlled by the operator.

If ventilating fans are running in the theater during the pictures, these in all probability must be stopped during the song, since the whirring of the fans, not at all objectionable during the pictures, would be decidedly so during the song. With an illustrated song an accompanist is required; this usually dispenses with the expense of an automatic piano, the accompanist playing during the intermissions. The operator in control of the program therefore is required to call the accompanist as the program nears the close, that the intermission music may start promptly at the close of the pictures.

What, then, are the total duties in such a theater which are required of the operator usually thought of as only a picture-machine operator?

Take the easiest form of song-and-picture program, in which the pictures follow the song.

In the intermission, the pianist is on duty. The operator, having his picture film in readiness, (1) lights his arc and (2) rings for the singer. He then (3) turns out the lights of the auditorium, (4) turns off the ventilating fans, (5) turns off the automatic barker and (6) projects the song slides in proper order and at the proper instant for each. At the conclusion of the song, he (7) shifts to the motion head and begins to turn the crank of the kinetoscope, and at the same time, with his free hand, (8) he turns on the ventilating fans and (9) turns on the automatic barker. This is the time for the accompanist's period of rest, and as the operator nears the end of the reel he (10) rings for the accompanist to be in readiness for the intermission. At the end of the motion pictures he (11) projects the *Please Remain* slide; then (12) turns on the auditorium lights, (13) cuts off the current from his arc light, (14) rewinds the film and (15) adjusts the carbons of his arc lamp. Last, but by no means least, the operator (16) decides the length of the intermission before repeating his routine of sixteen separate duties.

With every added feature of entertainment, the operator's duties become more complex.

An alternative plan of managing the performance consists of placing a *stage manager* at the theater entrance, inside the auditorium, and providing him there with all necessary control facilities. An array of electrical switches control the *barker*, the house lights and the ventilating fans; push buttons are arranged to ring buzzers or bells in the operator's booth and in the waiting room of the performers in the rear of the picture screen. An answering buzzer circuit may run from the waiting rooms to the stage manager's station, or even a telephone line may be installed. In the picture machine operator's booth there is merely one switch controlling the current for his arc lamp and one button which rings a buzzer at the stage manager's station.

This system operates as follows:

When the machine operator is in readiness, having rewound his films and adjusted his lamp, he signals to the stage manager by pushing his button; then he merely awaits the command to go ahead with the projection.

When, in the judgment of the stage manager, the performance shall begin, he rings for the singer and signals the operator (two buzzes for the song slides) and when the first slide flashes upon the screen the stage manager cuts off the house lights and stops the *barker* and the fans. With applause after the song, the stage manager uses his discretion as to whether an encore shall be sung, and either rings again for the singer and signals to the operator (three buzzes to put the chorus slide back on the screen) or rings one buzz to the picture machine operator to go ahead with the motion picture film without encore; at the same time, the stage manager starts the fans and the *barker*. As the pictures near the close, the stage manager rings for the pianist and then turns on the house lights as the picture closes. He then must wait for the buzz from the operator indicating that the projecting department is in readiness again.

When vaudeville or specialties of any kind are added to the performance, the duties of the stage manager become more complex, and the machine operator, whose post is a responsible one, should be relieved of them.

Keeping Up With the Times. The live projection operator who desires not only to give a good show and hold his present job but also to fit himself for a better one, must keep posted upon the new ideas that are being developed in the art of projecting and theater operating, and the new devices which are being produced constantly by enterprising manufacturers. Subscribe for some motion picture magazine, and read not only the feature articles of the magazine, which attract attention first because of their illustrations, but read the editorials and the advertisements. Read particularly, and with care, the department usually entitled "Manufacturer's Department" or "Notes of the Trade," a department which is a fusion of advertisement and editorial and which supplements both the advertising and editorial columns, illustrating and commenting upon almost every new thing which is produced in the motion picture business.

Buy the new books of the art as they are brought out by the publishers; read them and understand them as far as possible. Talk with everybody you meet in the picture business and add to your own knowledge whatever they know. Participate in the "Questions" columns of the motion picture magazine to which you subscribe, either with questions on the business or with contributions from your experience. Be alive, whether on or off duty. Then when some good, live manager needs a good, live operator and searches his memory he will remember YOU.

SCENE FROM PHOTOPLAY, "THE ROSE OF OLD ST. AUGUSTINE," OR "A TALE OF JEAN LAFITTE, THE PRIVATEER"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

THE SERGEANT'S DAUGHTER TESTIFIES AT THE TRIAL
Scene from Pathé film, "Lieutenantsliebe"
Courtesy of *Pathé Frères, New York and Paris*

SCENE FROM "MAKING BAMBOO HATS IN JAVA," BY ECLIPSE
Showing Some of the Educational Possibilities of Motography
Courtesy of the *Kleine Optical Co.*, *Chicago*

SCENE FROM PHOTOPLAY, "THE MINOR CHORD"
Courtesy of *Independent Moving Pictures Co., New York*

MOTION HEAD

PART II

SPECIFIC PROJECTING MACHINES

Introduction. The progress of the art prevents the presentation, in any one book, of instructions for operating all and every one of the projection machines used or offered for sale. A new detail is added to some standard machine every month, and perhaps an entirely new model is brought out by an old and well-established manufacturer, or a new manufacturer springs into the arena to fight for a part of the motion-picture trade with a projecting machine entirely new and entirely different in many or all of its mechanical details. To keep up with such development requires at least a monthly review of the new devices and improvements; this is afforded you by the trade magazines.

To understand the current news of improvements and to be able by reason of that understanding to operate any of the new devices with their peculiarities and special conveniences, the operator should master one machine thoroughly and learn to operate it perfectly so far as its particular mechanical details go. Then, or before then, he must master the theory of each operating part and regard the part of the projector which effects each function as being a little integral device in itself which may be replaced with an improved device designed to effect the same function, the improved device being built into the projector without changing any of the other details of the machine.

When an operator has attained a skill with any one machine that will enable him to operate it "with his eyes shut and one hand tied," and when he has added to this physical skill, the mental mastery of the separate results to be accomplished by the projector, and has learned how each mechanical detail of his projector is specific to one of these separate results, then it is a matter of minutes, not hours, before he becomes equally skilled with any machine with which he is confronted and is able to recognize its defects, its eccentricities, its bad adjustments, and its worn parts, and to adjust and replace them and give a good show with improved projection.

In some projectors, the feed reel magazine is square, in others it is round; the operator who has skill in placing a full reel of film in a square magazine cannot fail to have the skill to place it in a round one, nor will he forget to close and latch the door, nor forget to feed the end of the film down through the film outlet before closing and latching the door. In every other detail will skill in the operating of one machine lead to the operating of another.

A film outlet must hold a film close while passing through; it must have a release device to open the outlet if too close to push the end of the film through easily. The Edison outlet has but one pair of rollers, through which the end of the film is pushed easily. The Power's Cameragraph has a long film outlet with a pair of rollers at the lower end where the film cannot be pushed through easily, but one of the lower rollers, spring-pressed, is hung with its axle through slots and the ends of the axle project so as to be caught by the fingers, whereby the spring roller may be drawn back to open the outlet and let the end of the film freely through. The Edengraph and Motiograph use a four-roller trap so built that the rollers at one end are opposite a slot, and the end of the film may be carried into the rollers through the slot of the outlet.

Such small differences in mechanical detail will be all that is to be found in changing from one projector to another. Every projector has its feed reel, its feed reel magazine, its feed magazine film outlet, its upper steady feed, its upper feed loop, its film gate, its intermittent mechanism, its take-up. Every lamp has its four adjustments, as has been discussed and classified heretofore, and so on through the entire list of necessary functional apparatus units. Learn one, learn it well, and watch for the differences when taking charge of a strange machine.

In ordering repair parts for any projecting machine, give as much information to identify the machine as it is possible to give. To write to the Nicholas Power Company asking for a complete new intermittent mechanism seems hardly sufficient information. It may be assumed by the company when receiving the order that the mechanism is desired for a Power's Cameragraph, but the intermittent mechanism for the No. 5. Cameragraph is a Geneva, while the intermittent for the No. 6 Cameragraph is a pin-cross movement—and which one do you need? Some manufacturers change details or dimensions of parts without changing the number of the machine; for that reason, give the serial number if it can be found.

The serial number of the motion head is a number stamped upon the frame somewhere with numbering punches, just as a similar number is placed upon watches, bicycles, and pianos, for identification.

Write in this manner: "Please send me for Motiograph, 1910 model, serial number 1263, a framing device connector bar 167 and a crank handle 13½." The numbers of the parts are taken from the illustrated lists of repairs, if possible to identify them in the printed lists; if not, then the best description possible must be given, or if convenient to do so the worn or broken part may be sent for identification and duplication. Any lack of care in ordering is liable to produce an error in shipment, or to produce a delay by causing the dealer to write, asking for further information in order to enable him to fill the order.

In the following pages, complete instructions are given for a few leading machines, not only for operating them after they are set up, but for setting them up for beginning service. The later paragraphs will not repeat instructions where they are similar to those already given.

THE EDISON KINETOSCOPE

Installation. First, place the narrow side of the case up; remove the top cover; and check packing slip.

Remove packages in main compartment as follows: adjustable legs, rewind, condensers and lenses, cone and bracket, switch, cover and cords, lower magazines, lamp house with arc lamp, crank and lever inside, upper magazine, long baseboard. The small compartment contains the mechanism. The rheostat, completing the outfit, is shipped in a separate box.

Assembling. Place long baseboard, Figs. 37 and 38, on floor, bottom side up, and loosen thumb screws on flanges. Extend leg rods in all tubes and insert in flanges, fastening by means of leg clamp screws, adjusting to proper height by clamp screws provided.

INDEX OF PARTS

1 Carrying case
2 Base board
3 Base board wing nuts
4 Objective lens on front of cabinet
5 Lamp house
6 Lamp house casting

23 Hand wheel for lowering and raising lamp
24 Carbon feed lever
25 Lamp body lower binding post
26 Switch binding posts
27 Lamp body upper binding post

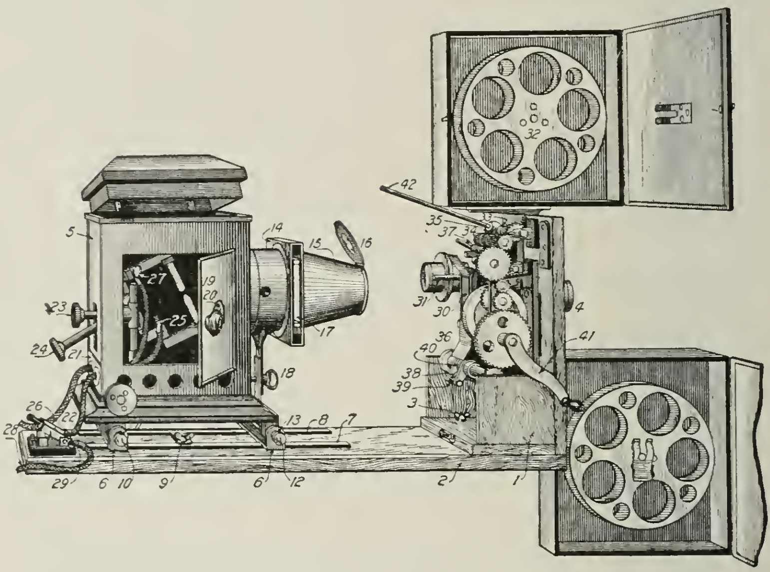


Fig. 37. Edison Exhibition Kinetoscope

7-8 Lamp house casting guides
9 Bolt and wing nut
10 Rear slide rod
11 Rear slide rod set screw
12 Front slide rod
13 Front slide rod set screw
14 Condensing lens holder
15 Condensing lens hood
16 Mica lid
17 Slide carrier frame
18 Condensing lens thumb bolt
19 Lamp house door
20 Ruby window in lamp house door
21 Rear door of lamp house
22 Hand wheel for backward and forward adjustment of lamp

28 To rheostat binding posts
29 Switch binding posts for the main circuit wires
30 Film aperture
31 Stereopticon support rod
32 Upper reel
33 Top idler
34 Top sprocket
35 Upper spring idler
36 Film gate
37 Upper gate idler
38 Film gate tension springs
39 Lower spring idler
40 Lower sprocket
41 Crank
42 Framing device lever

INDEX OF PARTS

1 Mica lid

2 Condensing lens hood

6 Lamp house door

7 Lamp house lid

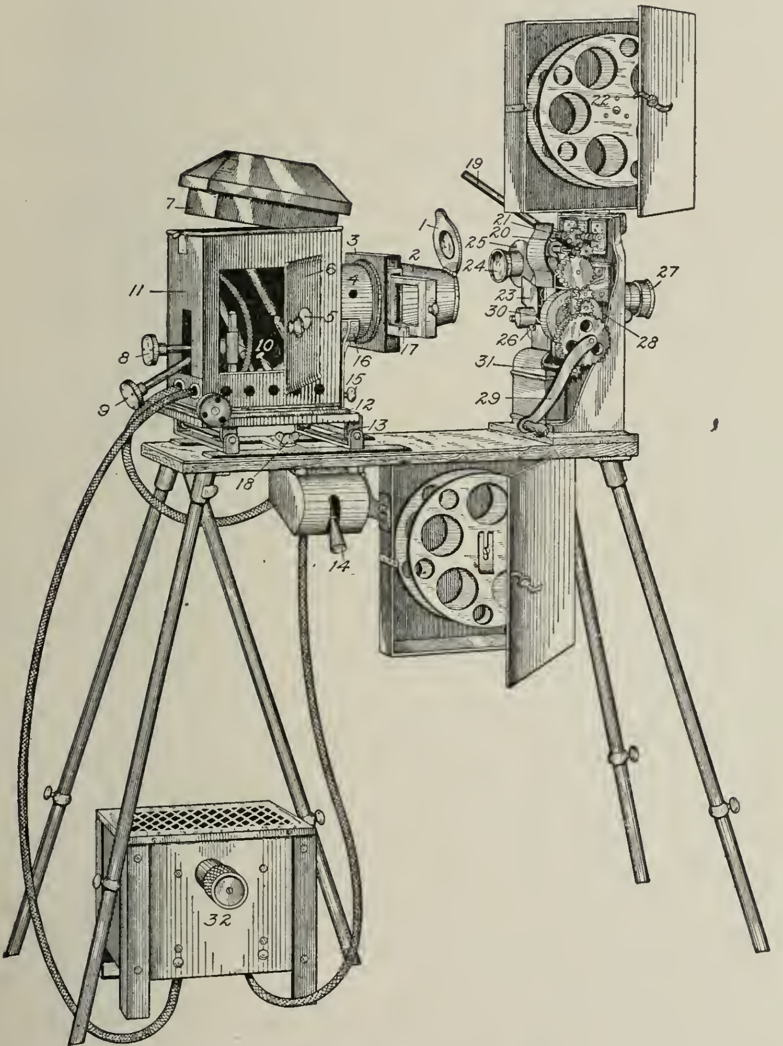


Fig. 38. Edison Kinetoscope, Underwriters' Model Type "B"

3 Slide carrier frame

4 Condensing lens holder

5 Ruby window in lamp house door

8 Hand wheel for lowering and raising lamp

9 Carbon feed lever

10 Lamp body lower binding post
11 Lamp house
12 Lamp house baseboard
13 Lamp house baseboard guides
14 Switch
15 Condensing lens thumb bolt
16 Cone holder casting
17 Slide carrier
18 Baseboard clamp casting thumb bolt
19 Framing device lever
20 Top sprocket
21 Top idler
22 Upper reel
23 Film gate
24 Stereopticon objective lens
25 Stereopticon ring casting
26 Film aperture
27 Position of objective lens on front of mechanism
28 Take-up attachment binding screws
29 Crank
30 Lower sprocket
31 Lower spring idler
32 Rheostat

Carefully unpack mechanism and remove mechanism cover by loosening thumb screws. Place mechanism on baseboard, securing it with wing nuts screwed in baseboard.

Assemble lower magazine with take-up by removing wing nut on take-up base and clamping long arm over shoulder screws on take-up bracket and base. Tighten center thumb screw directly under mechanism, then place long bolt over take-up sprocket shaft pulley passing it through slot in baseboard, then around small pulley next to magazine, over large pulley on take-up reel shaft, and under second small pulley. Adjust upper magazine and bracket to mechanism support by means of the thumb screws already displaced when mechanism was uncovered.

One film reel will be found in each magazine.

The winding crank, adjusting lever, and stereopticon attachment which will be found inside of lamp house, may now be attached to the mechanism in their respective places.

Adjust the stereopticon to the left side of the mechanism support by the thumb screw, washer, and wing nut provided.

The stereopticon lens and lens holder, which are already assembled, may now be placed on the stereopticon slide rod. Screw motion picture lens into position on front of mechanism support through the lens ring and flange already attached to support.

Lamp House. Loosen the two small set screws over the round opening provided for slide rods in lamp house bracket. Place the lamp house and lamp house baseboard on this bracket with that side of the lamp house containing a large round opening, toward the mechanism. Insert the two slide rods through round openings in bracket, and through slide castings, being sure that the flanged ends of rods are on the stereopticon side of the lamp house. Tighten the two set screws in lamp house bracket above referred to, to hold the rods in position. These rods must not project beyond the edge of the casting where they are fastened with the set screws. Place the rear slide or door of lamp house in position.

Cone and Bracket. Place the condensers in cone, and set the same in position, in front of lamp house, fitting it in the round opening of lamp house, and passing the cone bracket over the thumb screws which will be found in the casting attached to the front of the lamp house baseboard, then tighten the thumb screw. When placing condensing lenses in cone, be sure that the side of the condenser with threaded ring will be in position next to the arc lamp. Place slide carrier in cone, where provided.

Arc Lamp. This will be found packed inside the lamp house; remove, clean interior of lamp house, set the arc lamp in lamp base by placing the stud at bottom of lamp post in the socket in center of lamp base, then tignten round head screw, so that the lamp may not be jarred out of position, when operating. Attach ends of asbestos-covered connecting wires by removing the binding post thumb screws on upper and lower carbon holder bases. The short connecting cord should be attached to the lower carbon holder, and the long connecting cord to the upper carbon holder.

Operation. *Carbons.* For *direct current,* the upper carbon should always be the positive pole, while the lower should be the negative pole, and the latter set $\frac{1}{8}$ inch in advance of the former so that a crater will form in a position toward the condensers. With carbons of the same diameter, the positive burns twice as rapidly as the negative, thereby requiring more or less adjusting downward to keep the crater in the optical axis, for this reason some operators prefer a $\frac{5}{8}$-inch soft cored upper, or positive, carbon and a $\frac{1}{2}$-inch hard carbon in the lower, or negative, carbon holder.

This difference in cross-section compensates in the matter of lineal consumption, and the crater is kept in its proper place with less difficulty. The carbons, when burning, should be kept at all times as near to $\frac{3}{16}$ inch apart as possible. Most satisfactory results are obtained from D. C. when using from 20 to 25 amperes.

Where *alternating current* is used, the carbons should be set in alignment, although some operators claim to get better results by placing the lower carbon slightly in advance of the upper. This, however, is a matter of choice, and the careful operator will usually experiment in the adjustment of the lower carbon until he gets it in a position most satisfactory to himself.

Both carbons should be soft cored, and kept as nearly as possible to $\frac{1}{8}$ inch apart. They are consumed at about the same rate, the upper carbon about 8 per cent more rapidly than the lower, owing to the upper tendency of the flame.

The most satisfactory results are obtained on alternating current using from 35 to 50 amperes.

Focusing. Adjust the lamp house by means of sliding base on bracket to a distance of 16 inches between lamp house and aperture or picture gate; open film gate on mechanism, and proceed to regulate lamp by using adjusting handle below lamp house hinged door. Slide either backward or forward until you have obtained a white spot $1\frac{3}{4}$ inches in diameter covering the opening in the picture gate. For vertical adjustment, use upright adjusting handle on the arc lamp post. Adjust the projecting lens so as to have a sharp outline of opening in picture gate on the screen.

Stereopticon Lens. Slide the lamp house on the slide rods to the flanged ends. Adjust stereopticon lens in front of the condensed rays, sliding either backward or forward on stereopticon slide rods, until the proper focus is obtained. Adjusting the stereopticon lens in this manner permits of sliding the lamp house from side to side, alternating between motion picture objective lens, and stereopticon lens as desired, without rearranging either arc lamp position or lamp house position.

Connecting Cords. The free end of the short cord to be attached to a contact on that side of the switch where no open poles are placed. The free end of the long connecting cord attached to the upper carbon holder to be fastened to one binding post in rheostat or transformer. The second long attaching cord to be placed on the second contact of switch where no pole is placed, with the other end attached to the second binding post in rheostat or transformer.

Take-up Device. The take-up device comes detached from the head piece mechanism, and is adjusted as follows: Insert the left-hand part of the take-up device, Fig. 39, through the hole in the lower part of the cabinet. The hooks *3* on the frame casting of the take-up device hang on the half-inch stud in the lower part of the head piece mechanism. The lugs *4* are fastened into position with two 8-32 machine screws. When the film has been threaded, as described, and fastened to the spring clip of the core of the take-up reel, and the crank handle is turned, the film will be wound on the reel as fast as it comes through the machine. If the reel does not revolve fast enough, the friction adjusting nut *5* should be screwed in, thus causing the friction wheel *6* to engage friction disk *7*, causing the reel to revolve faster and take up all the slack. The lever *8* is used to disengage the friction wheel from the friction disk and is only used when the film is rewound from the take-up reel to the top reel. When the film is rewinding, this lever should be thrown back toward the reel. At all other

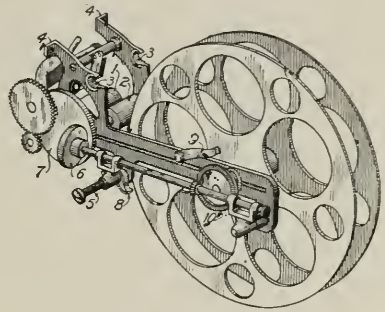


Fig. 39. Take-Up Device

INDEX OF PARTS

1	Lower sprocket	6	Take-up friction wheel
2	Lower idler pulley	7	Take-up friction disk
3	Take-up frame hooks	8	Disengaging lever
4	Take-up frame lugs	9	Momentum friction spring
5	Take-up friction adjusting nut	10	Crown gear

times the handle of the lever should point outward. When the film is rewinding, use the friction spring *9*, to check its momentum if it turns too fast. This is accomplished by pressing down the spring until the end rubs against the inside of the crown gear *10*. This spring is only used when the film is rewinding. At all other times it should stand in position as indicated on Fig. 39.

Wiring. The binding post *10*, Fig. 40, on the lamp connects by short wire with switch binding post, and the lamp binding post *11* connects by long wire with rheostat binding post.

The interior of the lamp house is planned for all lights known to exhibitors, including the electric arc light, for both alternating and direct current, the oxy-hydrogen (or calcium) burner, the Edison gaso-oxygen burner, or the methyl-etho saturator. Assuming now that we are assembling the electric burner, observe the following rules, and refer to Fig. 40. The lamp base *1* is assembled in the lamp house. Place lamp post *3* in socket *4* and tighten with binding screw. Next place carbon in carbon holders *14* and tighten carbons with thumb screws *9*. The lamp being now in the lamp house, is ready to receive the wires *12*.

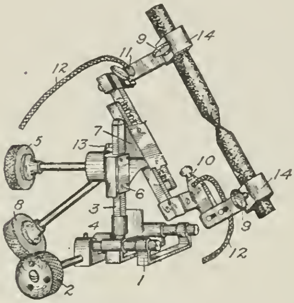


Fig. 40. Calcium or Gaso-Oxygen Light

The main line should be wired for 110 volts direct current, or 52 or 104 volts alternating current, 25 to 40 amperes, using a standard 30-ampere cut-out, or combination switch and fuse block with 40-ampere fuses. If alternating current, 60-ampere fuse may be used.

When the wires *12* are connected, the carbons are brought together by raising the feed lever *8* to make the arc. After closing the circuit through the car-

INDEX OF PARTS

1 Arc lamp base
2 Hand wheel for forward and backward adjustment
3 Lamp post
4 Lamp post base socket
5 Hand wheel for lowering and raising
6 Lamp post friction screw
7 Lamp body
8 Carbon feed lever
9 Carbon holder thumb screws
10 Lamp body lower binding post
11 Lamp body upper binding post
12 Wires
13 Raising and lowering lever friction screw
14 Carbon holders
A. Socket for alternating current
D. Socket for direct current

bons, they should be separated about ¼ inch to make a perfect arc. This is done by lowering the feed lever slightly. A perfect circle of white light should cover the aperture *30*, Figs. 37 or 38. All this is done before the film is threaded into the mechanism. Should the circle of light on the aperture be imperfect, it may be remedied by either or all of the following adjustments:

By swinging the lamp either to the left or right (revolving on the lamp pcst), using the hand wheel *5*, Fig. 40, as a lever; or by raising or lowering the lamp by turning hand wheel *5*, or by a forward and back adjustment by hand wheel *2*. The size of the circle light covering the aperture can be increased or diminished by sliding the lamp backward or forward.

If a "ghost," or dark spot, appears in the middle of the screen, this can be remedied by sliding the entire lamp house backward or forward on the large baseboard.

The set screw and tension device *6* is placed on the lamp for the purpose of giving an amount of friction necessary to prevent the lamp from dropping on the post from its own weight. This set screw should be snugly tight, but not tight enough to bind. The set screw *13* is for tightening the friction bushing on shaft of handle *5*. This also prevents the lamp from dropping from its own weight. This, however, should not be too tight.

Six Edison Rules. *First.* Adjust the height by raising or lowering the lamp on the lamp post *3* by the hand wheel *5*, Fig. 40, until the points of the carbons, when brought together, are opposite the center of the condensing lens.

Second. Turn on the current by closing knife switch. Lift up mica lid *16*, Fig. 37. The revolving mica shutter behind the framing plate should be turned so as to leave the space between the framing plate and the objective lens entirely clear. This should be done before the film is placed in the machine.

Third. The lamp should then be adjusted by moving backward or forward until a bright, clear, round light just covers the square hole in the framing plate. If the circle of light is too large, light is lost and the brightness of the picture is impaired. When properly adjusted, the light on the screen will be bright and free from color.

Fourth. The operator should adjust the objective lens by turning the focusing screw, until the square on the screen is sharply defined. Only a slight adjustment is then required to sharpen the picture when projected.

Fifth. *All* this should be done *before* the film is threaded up.

Sixth. *Never turn the light on the film until it is in motion,* and if by accident or mistake the film should stop while the light is on, shut mica lid *16*, Fig. 37, at once, or the film will catch fire.

Calcium or Gaso-Oxygen Light. When calcium or gaso-oxygen light is used by the operator, the arc lamp base *1*, Fig. 40, remains in position on the floor of the lamp house. Into the socket *4* is inserted the eccentric holder post, with which every complete projecting kinetoscope is equipped. The post must not be clamped too tightly; it must be loose enough to permit the eccentric holder to move to right or left and forward or back, as may be necessary in centering the light on the condenser. The clamp screw may be tightened after the center is found.

Directions for Operating. Remove jet from lantern to place lime pencil in straight position into lime cup within ¼ inch from point of jet.

Turn on the hydrogen gas (black cylinder) first until the flame becomes the size of a light from an ordinary gas burner. Then turn the oxygen gas (red cylinder) slowly until the light gets bright and dazzling. Too much oxygen dulls the light and may extinguish it; yellowish flames of hydrogen should always be noticed around the lime pencil. If not intense enough, add small portions of the gases until the light is nearly hissing. Turn off oxygen first and then hydrogen.

Turn lime pencil about every few minutes, to prevent cracking of condensers and see that no draft strikes the lantern.

If light snaps out, shut off both gases and re-light as above stated.

Observe rules 3, 4, 5, and 6 above.

The gaso-oxygen saturator and burner are especially adapted for traveling exhibition purposes, and also for home use. A complete description of the gaso-oxygen outfit, together with directions for generating the gas and adjusting the burner, will be found under the heading "Directions for Operating the Gaso-Oxygen Light." Rules 3, 4, 5 and 6, above, must be carefully observed.

Threading up the Film. The film is wound on the upper reel *32*, Fig. 37, by placing the end in the spring clip on the core of the reel. The emulsion side, that is, the gelatine side, should be in. When the reel is full, the end of the film is brought under the lower front side of the reel. It passes over top idler *33*, under top sprocket *34*, over the upper spring idler *35*. Now open film gate *36*.

Engage the film on the intermittent or middle sprocket (not shown in cut), leaving about $3\frac{1}{2}$ inches of the film slack. The gate is then closed and secured by latch, thus forcing the slack film into a loop, the lower part of which passes behind the upper gate idler *37*, as shown. The film is now between the framing plate and the film gate *36*. As it passes the aperture *30* the film is held against the framing plate by the springs *38*. This checks the momentum of the film and prevents the center of film from touching the gate, thus avoiding possibility of scratching.

A second loop is then formed. This is known as the lower loop and should be about 2 inches in length. This is formed by passing the film under the lower take-up sprocket and over the grooved idler spring pulley, which is closed against the film to hold it firmly against the lower sprocket. Having then formed both loops, and the picture sitting squarely between the tension springs *38* and grooved framing plate, the film is next passed over the hard rubber roller, which will be found immediately in front of the lower take-up sprocket. The end of film is then passed under the core of the take-up reel and secured by the steel clip on the core. The machine is then ready to be set in motion, which is done by turning the crank *41* away from the operator. The framing lever *42* should be adjusted with set screws bearing on the flat surfaces of the lever. The picture is then framed upon the screen by lowering or raising the lever.

The emulsion side of the film should be always toward the light and the picture should show in the aperture upside down.

Framing Device. As has been noted there is no setting or adjusting of the film as it passes over the frame plate. This is rendered unnecessary by the framing device. After the picture appears on the screen, if it is not framed exactly, it is very easily accomplished by raising or lowering the lever *42* until the proper effect is obtained.

Adjustable Rheostat. After the rheostat is placed in circuit as described under the heading "Wiring," the current may be regulated by raising or lowering the contact spring. Before turning on light, the contact spring should be set at the bottom of the rheostat so as to prevent too much current being drawn suddenly, and burning out fuses. If, after lighting the lamp, the light is not strong enough, raise the contact spring until the desired strength is obtained.

General Instructions. The intermittent sprocket shaft is provided with bronze eccentric bushings, and set screws are placed in the cast frame to hold these bushings secure. The idea of making the bushings eccentric is to permit the operator to adjust them so that the star wheel and cam fit perfectly, thus avoiding unsteady pictures. If you wish to show steady pictures upon the screen at all times, it is necessary to look carefully to the adjustment of these eccentric bushings, and when these eccentric bushings, or the star wheel or cam, or the intermittent sprocket become worn, it is highly essential to good results that they be replaced at once. See that all set screws are kept tight, and the machine well oiled, so that it will run smoothly and regularly at all times. Be careful not to use too much oil, as surplus oil is liable to spatter on the film and damage it.

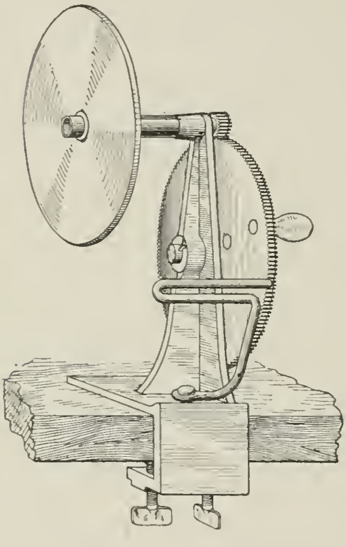


Fig. 41. Film Winder

Films should be handled carefully and kept clean and free from dust.

They should be wound on reels when not in use, and placed in a dust-proof reel box, and if possible kept in a cool, dry place.

The films should be kept in perfect condition, any broken places being mended at once.

Film Winder. This ingenious little apparatus, Fig. 41, is a great labor-saver. It is small and compact and can be placed on any table or shelf that may be near the projecting machine, being provided with thumb screws for instantly adjusting it to a table. If a Kinetoscope is not equipped with a take-up reel, this film winder is an absolute necessity.

After the film has been run through the projecting machine the end is placed in the groove of the winding shaft with the emulsion side *in;* and by turning the crank of the winder slowly, a 100-foot film can be properly wound in less than ten seconds of time. There is an attachment on the winder for removing the film from the shaft after it has been wound, in perfect safety and in a perfect roll.

This attachment consists of a nickel-plated disk of about the diameter of a 150-foot film when rolled up. This disk slides from

THE BOLD, BAD MAN, PROVES TO BE MERELY THE UNFORTUNATE, BUT AWFUL BROTHER

Scene from Photoplay, "That Awful Brother"

Courtesy of *Lubin Manufacturing Company, Philadelphia*

THE MEXICAN PROSPECTOR RESCUES GEORGE MAXWELL IN THE NICK OF TIME
Scene from Photoplay, "The Lucky Card"
Courtesy of *Essanay Film Mfg. Co., Chicago*

front to back of the shaft. After the film is wound, the exhibitor slides the disk from back to front carrying the roll of film with it, thus freeing it from the shaft.

Edison Film Mender. First open all gates. Place one end of the film on left-hand side of repairer, emulsion side up, with the bottom line of picture as near the center of the glass as possible, then close and clamp left-hand gate over the film. Place the widest part of the gauge, which forms part of the repairing outfit, against the closed gate, and, holding it firmly on the film, take a sharp knife and cut off that portion of the film which projects beyond the gauge.

Next, reverse the gauge, place it with the narrowest part over the film and close against the locked gate, moistening that portion of the film which projects beyond the gauge, and scrape off the emulsion. For this use a moderately sharp knife. Be careful not to scratch away the celluloid. After this is done, open the gate and move back the film so that it will be entirely covered by the gate, and re-lock the gate.

Next take the other end of the film, place it on the right-hand end of the repairer in the same manner as was done before, with the picture line as near the center of the glass as possible. Use the gauge in the same manner as before, that is, use the widest side and cut off that portion of the film which projects. This end of the film should not be moistened, nor should the emulsion be scraped away.

After this is done, release the left-hand gate and place that end of the film in the same position as it was after the first operation had been performed. You will then note that the ends will overlap about $\frac{1}{8}$ of an inch. Moisten both ends of the film with the film cement where they overlap, cement the two ends together carefully and smoothly (the one with the emulsion scraped off underneath), close down the center door or gate and lock same securely. Leave the film in this position for from 20 to 30 seconds, when same will be thoroughly cemented together.

When about to take the film from the repairer, open the center gate first and if the film is found to adhere to same, by working same carefully to the right and left the film will be released from the gate without breaking the joint.

Operating Gaso=Oxygen Light. The gaso-oxygen light is the result of a series of exhaustive experiments, and it is offered frequently as a substitute for the methyl-etho light outfit, for the reason that it is strong, simple, and cheap to operate. The operation of the light is very simple, and in order to make it perfectly clear, the directions are given under three different headings, as follows: (1) the chemicals; (2) the oxygen generator; (3) the gaso-oxygen saturator and burner.

Necessary Chemicals. The necessary chemicals can be obtained in almost any large town if the original supply becomes exhausted. Buy the chemicals from a reliable druggist, and see that there are no chips or other combustibles mixed with the chlorate of potash or the black manganese. The following chemicals will suffice for two hours continuous running: 2 lbs. chlorate of potash, and $\frac{1}{2}$ lb. black manganese (in the retort *1*, Fig. 42), $1\frac{1}{4}$ pints 90 deg. gasoline (in the saturator), and 1 lime pencil.

Mix 4 parts of chlorate of potash and 1 part of black manganese thoroughly and distribute it equally along the entire length of the retort *1*. Turn the retort so that the seam comes on top.

FOR GENERATING OXYGEN GAS INTO GAS BAG ONLY

1 1 Russia iron retort and cleaner $3\frac{1}{2} \times 18$
2 1 Retort stand
3 1 Burner (gas or spirit)
4 16-inch lined tubing from retort to purifier
5 2 Purifiers, complete with rubber stoppers, glass and metal tubes
6 6-ft. rubber tubing $\frac{3}{8} \times$ 3-16 connecting purifiers to gas bag
7 1 55-gal. gas bag, stopcocks and regulator
8 5-ft. rubber tubing $\frac{1}{4} \times \frac{1}{8}$ from gas bag to light

FOR GENERATING AND COMPRESSING OXYGEN GAS

1 1 Russia iron retort and cleaner, $3\frac{1}{2} \times 18$
2 1 Retort stand
3 1 Burner (gas or spirit)
4 16-inch lined tubing from retort to purifier
5 2 Purifiers complete, with rubber stoppers, glass and metal tubes
6 6-ft. rubber tubing $\frac{3}{8} \times$3-16 connecting purifiers and gas bag
7 1 55-gal. gas bag and double stopcock.
8 5-ft. rubber tubing $\frac{3}{8} \times$3-16 from gas bag to pump.
9 1 Compressor
10 5-ft. lined tubing and couplings from compressor to cylinder
11 1 gauge attachment, regulator and 5-ft. tubing to light
12 1 25-ft. cylinder and key

Fill the retort *1* as above. Connect the purifiers *5* as shown in Fig. 42. The purifiers should be half filled with pure water and ¼ ounce of caustic soda placed in bottle nearest the retort. Be careful that the ends of tubes *AA* are *below* the surface of the water and the ends of tubes *BB*, *above* the water.

The gas bag *7* should be rolled before connecting, to eject all air. Place the burner *3* on retort stand *2* at one end of the retort *1*. Gas will generate as soon as heat is applied. Allow a little oxygen to be given off, before finally connecting the retort *1* with the tubing *4* to the first purifier *5*. To ascertain when the gas is pure, light

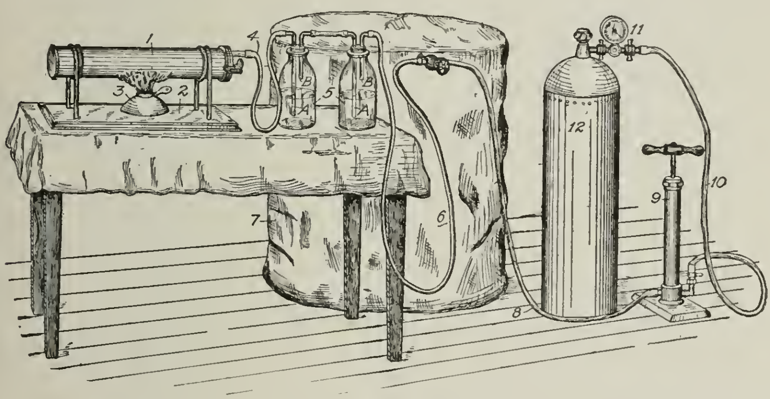


Fig. 42. Oxygen Generator

a piece of brown paper, *then blow it out*, and hold the *smoldering* portion in front of the arm of the retort *1*. When the gas is pure, the paper will burst into flame; then connect with tube *4* and see that all the tubes are straight. Now open the tap of the gas bag *7*. Scores of people forget to do this. The gas bag *7* is now filling with pure oxygen gas. Move the burner *3* along under the retort *1* inch by inch until the chemicals are exhausted. As soon as the bag is quite full, turn off the tap at gas bag, remove the burner from the retort, and disconnect the tubing.

When using the gas bag a pressure of 150 to 200 pounds is required to procure the best results, which is obtained by means of press boards and weights. The capacity of the gas bag is 55 gallons, and about 2 pounds of chemicals must be used to fill it completely.

The gas bag should be kept in a warm place when not in use.

Wash out the retort with hot water as soon as possible, and do not attempt to pick out the baked residue with a chisel or other sharp instrument, as this spoils the retort. Don't leave mixture to harden; unless the retort is cleaned at once, it is almost impossible to remove the hardened residue.

When the high-pressure method is used, the oxygen gas is compressed into cylinder *12* with the compressor *9* until about 100 pounds pressure is reached in cylinder *12*.

Gaso=Oxygen Saturator and Burner. The gauge attachment, Fig. 43, is supplied with two needle valves; turn on first the one leading to the saturator, see that valves *C* and *D* are also open, and light the jet, then turn on the oxygen from valve *B*, and regulate your light in the same manner as oxy-hydrogen gas is used, until

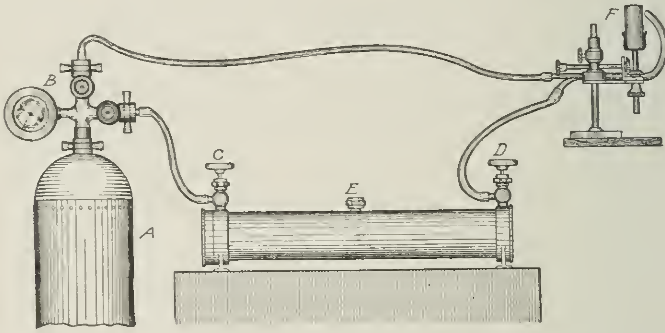


Fig. 43. Gaso-Oxygen Saturator and Burner

the light is bright and dazzling. Too much oxygen dulls the light, and may extinguish it. Little red flames should always be noticed around the light, to show that sufficient gasoline or ether is supplied. If the light is not intense enough, add small portions of the gases until the light is nearly hissing.

Always turn on the gasoline first when lighting, and when through, turn off the oxygen first. Have the lime pencil properly adjusted about $\frac{3}{4}$ inch above the point of the jet when starting, and turn the pencil upward about every five minutes, to prevent the flame from burning through the pencil and striking back against the condenser, as this will crack it. See that no draft strikes the lantern, thereby causing the condenser to break.

Should the light snap out, it is a sign that too much oxygen is used, then both gases must be turned off, and relighted as above directed.

It is imperative that 90-degree gasoline only is used, as lower grades will not evaporate quickly enough to give sufficient supply of lighting material.

In changing the fluid from gasoline to ether, it is necessary to open the saturator, take out the cotton, and have it thoroughly cleaned, by exposing it to the air until it is perfectly dry.

Note the following differences over the other saturators:

Ninety-degree Gasoline or Sulphuric Ether can be used with utmost and absolute safety, as there is no direct connection between fluid and flame and consequently no danger. Any number of lights can be run from one saturator, and any single or dissolving lantern jet, or dissolving key can be adapted.

The 1,000 candle-power jets give the same light with gasoline saturator, as with oxy-hydrogen gases.

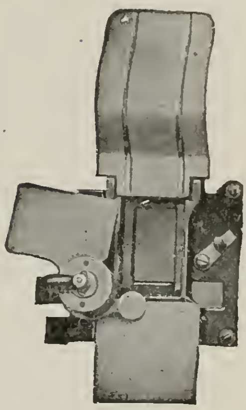


Fig. 44. Automatic Shutter for Underwriters' Model of Edison Kinetoscope

The saturator is equipped with needle valves and regulators, guaranteed air tight.

If no cylinder is used, and the oxygen gas is supplied direct from the gas bag, it is necessary to use a stand with two-way connections near the saturator to regulate the gases conveniently, in the same manner as above described.

Automatic Shutter. *On Underwriters' Model.* Under no possible conditions can the light be thrown upon the film except when the film is in motion. When the shutter, Fig. 44, is wide open it automatically locks so that no power is required to keep it open, eliminating undue wear on the gearing and causing easier operation of mechanism. When the speed of the machine falls below a certain point, however, it automatically unlocks and closes.

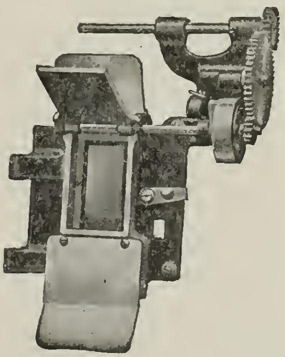


Fig. 45. Automatic Shutter for Exhibition Model of Edison Kinetoscope

On Exhibition Model. This very simple but effective device automatically shuts off the light when the film is at rest, and absolutely prevents the light being thrown upon the film except when the latter is in full motion.

This shutter, Fig. 45, consists essentially of two parts: a film gate, upon which is mounted a metallic shutter and centrifugal governor, and a casting upon which is mounted an intermediate gearing, through which the shutter is connected to and operated by the large driving gear.

The exhibition automatic shutter is not regularly furnished with the improved exhibition model machine, but is attached, at an extra charge, when ordering a machine.

Rheostats. The question of rheostats is one about which there has been much discussion and diversity of opinion, due principally to a lack of knowledge of real conditions. It is not practical to make what might be termed a "universal rheostat" or one equally well adapted to meet all conditions. A rheostat with a capacity of 25 to 40 amperes on *direct-current* circuits of 100–125 volts will give perfectly satisfactory results under ordinary conditions in the hands of an intelligent operator. To get equally satisfactory results with *alternating current*, 35 to 60 amperes are required with the same line voltage. For direct-current circuits of 100–125 volts, the Underwriters' Model (coil type) rheostat is recommended, and the Underwriters' Model (type "B") for alternating-current circuits, on account of its greater capacity. The latter will give equally satisfactory results on both direct- and alternating-current circuits of 100-125 volts, *but on direct-current circuits care should be taken to adjust it so that not more than 25 to 40 amperes are consumed in the line.*

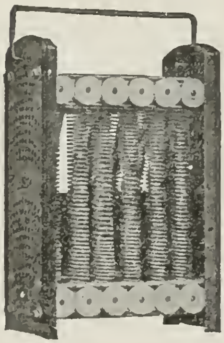


Fig. 46 Coil Type Rheostat

The coil type rheostat, Fig. 46, is regularly furnished with the exhibition model projecting Kinetoscope, while the new grid type, Fig. 47, is supplied with the Underwriters' Model machine.

In the design and construction of the grid type rheostat the old-style wire resistance coils have been discarded and replaced with *cast metal grids*, supported and insulated by water and fireproof material.

The rheostat can be used on either direct or alternating current of any frequency, with equally good results, and in either case a maximum current can be obtained *without excessive heating* on a line voltage varying from 100 to 125 volts.

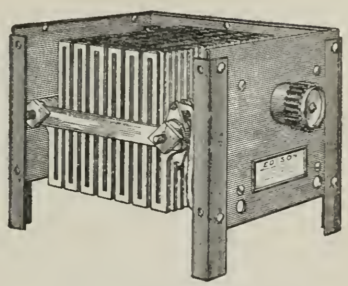


Fig. 47. Grid Type Rheostat

The front, back, and sides are enclosed with solid sheet metal, while the top and bottom are enclosed with perforated sheet metal.

The operating switch, switch contacts, and binding posts are all inside the sheet metal frame and are thoroughly protected from outside contact. The switch handle is outside the sheet metal case and a pointer indicates the position of the switch.

TABLE I

Projection with Edison Lenses

No. 1 M. P. Lens No. 4 " " No. 1A Stereo. Lens No. 1AA " "	Project a picture 3 ft. wide for every 10 feet of distance.
No. 2 M. P. Lens No. 5 " " No. 2A Stereo Lens	Project a picture 3 ft. wide for every 13 feet of distance.
No. 3 M. P. Lens No. 6 " " No. 3A Stereo. Lens	Project a picture 3 ft. wide for every 19 feet of distance.

THE MOTIOGRAPH

How to Install or Set Up the Motiograph. The complete machine and equipment Fig. 48, comes packed in a single case. Take out all the parts and see that all are wiped free from dust and that none are left in the packing case or overlooked in the packing material.

The mechanism base, lamp house, sliding frame, backward and forward slide rods and brackets are screwed to the baseboard. The arc lamp, saddle, post, etc., will be found inside the lamp house.

When the pedestal base is used to support the Motiograph it should be fastened very firmly to the floor with $\frac{3}{8}$-inch lag screws, large square head wood screws, of good size, and care should be taken to see that as nearly as possible contact with the floor is had on all sides. In order to do this, as a rule, it is advisable to use wedges of hard wood. It will be well to screw the base tightly to the floor and then drive the wedges just tight enough at different points so the base will rest with equal pressure on all sides.

To assemble the equipment set the lamp house in position on the lamp house slide frame, and insert the two cross slide rods through

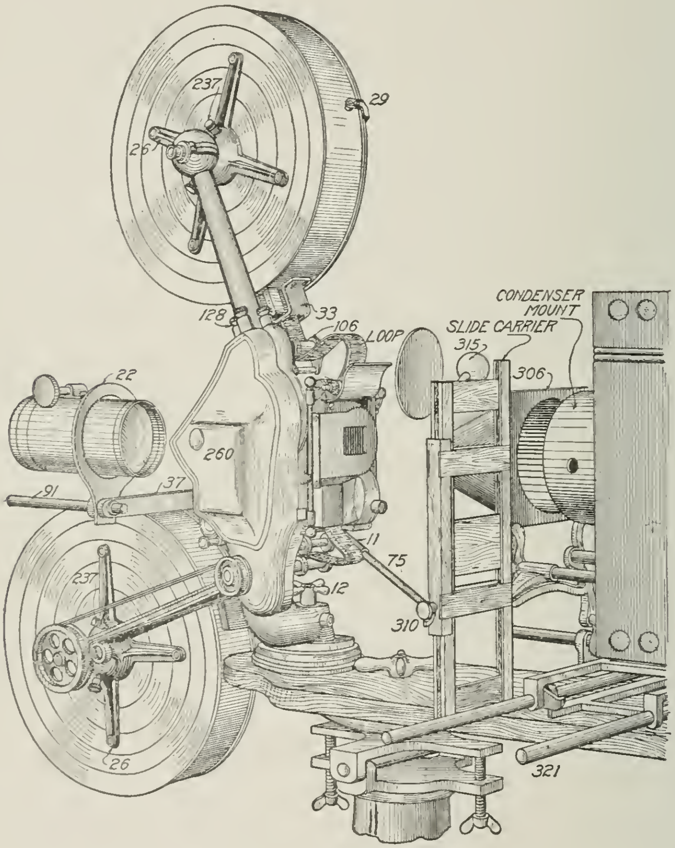


Fig. 48. Details of Motiograph

the ears on both the lamp-house base and the sliding frame, screw-end first, and screw them into the ears in the sliding frame that comes next to the operator, which is the right side when looking from the rear toward the front of the instrument. Set the Motiograph mechanism on the circular swivel base *2* and screw down the swivel thumb wheel. (Cut above shows the 1908 and 1909 Models with thumb wheel *12* on top of the base. The thumb wheel for the 1910 Model is larger and is under the base.) Attach the upper reel arm *7A* by entering the shaft and cross pin into the rewind vertical socket arbor, and screw into place with the three reel arm thumb screws *128*. Attach the take-up or lower reel arm *9A*, Fig. 49, with the three reel-arm thumb screws *237*. Place the take-up belt in position on the take-up pulleys with the idler pulley under the belt, first having loosened the tension screw of the belt idler *109* until the belt is quite loose.

Remove the objective lens from the little pasteboard box and screw it into position on the front plate of the mechanism, first having removed with a soft cotton handkerchief any dust that may have accumulated on either the front or rear surface of the lens. Be sure that the extension collar is in place, if the lens is of such focus that it requires one. Otherwise the lens can be brought to the focal point. Place the framing lever handle *75* in the framing lever socket *11*, and screw it into place. Loosen the little thumb screw on the crank *13A*, place the crank in position on the crank arbor and tighten the little thumb screw on the crank so it engages with the groove in the crank arbor to hold the crank in place. Remove the stereopticon lens bracket screw and attach the stereopticon lens bracket *37*. Attach the stereopticon lens ring to slide rod on stereopticon lens bracket, tightening into place with the thumb screw. Remove the stereopticon lens from its box, carefully wipe from the surface of the lens any dust that may have accumulated, remove the flange ring from the lens. Insert it back of the lens ring with the bead or rim to the front; insert the lens and screw it in place. It is unnecessary to have the flange ring attached to the cast ring or to have the cast ring threaded.

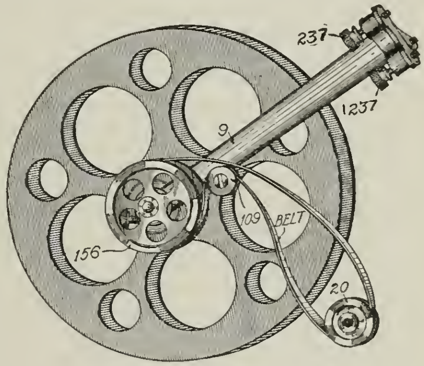


Fig. 49. Take-Up Device

The location of the stereopticon objective lens on the rod support should be such that the distance from about the center of the lens (from front to back) and the front surface of the front condensing lens is equal to the focal length of the lens. For example, a stereopticon lens of $12\frac{1}{2}$-inch focus should be located so that the distance from the middle of the stereopticon objective lens to the front of the condensing lens is about 12 inches when the rack adjustment of the lens is so set that it will allow of liberal adjustment in either direction. The stereopticon lens bracket rod may be screwed into either the front or the rear of the bracket depending on the focal length of the lens.

The universal reel clamp is used for the 1908 and 1909 Models No. 1 and No. 2 machines It will be found clamped on the reel arbor. This should be removed by holding the clamp with one thumb and finger and loosening the thumb screw with the other. This will loosen the clamp and it may be slipped off the arbor. Now put the reels in place on the arbor, and turn around until the key pin on the arbor enters the seat (hole or keyway) in the reel. Slip on the universal clamp with the projecting pin next to the reel, insert the pin into the keyway or slot in the core block of the reel, and tighten the clamp thumb nut, which will hold the reel securely on the arbor. The universal reel clamp has been dispensed with for the Model No. 1A for 1910 and a new arrangement called a *jointed reel shaft latch* is used.

When fireproof magazines are to be used, they should be attached before the reels are put in place. To attach the fireproof magazines unscrew the two thumb screws in the magazine spiders *26*, so as to let their points pass the flange on the reel arm, put the magazine in place on the reel arm by inserting the boss on the reel arm into the opening of the spider. Have the fire trap or valve toward the upper or lower feeding sprocket (depending on which of the reel arms you are assembling), tighten the thumb screws to engage the flange on the reel arm. Now, open the magazine and attach the reel in the same manner as in instructions previously given. The magazines are marked on the inside "upper" or "lower."

The condensing lenses are mounted in a nickel-plated mount and are held in by the use of two inside telescopic bands. The condenser mount is held in position on the front of the lamp house by two clamps and two screws. The mount may be removed from the lamp house front, for changing or cleaning the lenses, by turning the two clamps until the flattened sides of the clamps come next to the flange of the condenser mount. The mount is usually left attached to the lamp house for shipment. The flat side of the condensers should always be outward and the convex sides toward each other. The surfaces of the condensing lenses should be free from dust, perspiration, or other accumulations to insure the unobstructed passage of the light.

The No. 1A 1910 framing device, Fig. 50, can be used in the 1909 No. 1 or No. 2 mechanisms by buying the short connecting link *107A* to connect the framing handle with the framing device, and the 1909 framing device, Fig. 51, may be used in the 1910 machine by using the 1909 link *167*. Both framing devices are practically alike with the exception of the vertical casting, which can be interchanged

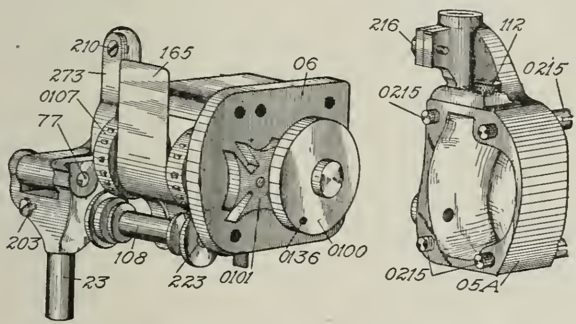


Fig. 50. Motiograph 1A 1910 Model Framing Device

between the two, and the change can be made from one to the other by removing the four screws in the side.

Attach the stereopticon slide carrier to the lamp-house slide carrier swing *310*, and clamp in position with the thumb screw on top of the carrier swing. If the lamp house cone *377* has been removed for convenience in packing for transit, it is to be attached by inserting the two dowel pins in lamp-house support *306* and will be held in place by the two small thumb screws on the side of the cone support.

Test the slide on the lamp house and see that it slides freely on the backward and forward and the sidewise movements.

The proper adjustment for the lamp house on the backward and forward slide should be a point where the distance between the front face of the condensing lenses and the film on mechanism will be about 12½ inches when operating at a distance of about 60 feet from the screen with a picture of moderate size. When operating a greater distance from the screen, the distance between the condensing lenses and the aperture plate should be greater, depending on the length of focus of the condensing and objective lenses that are being used and the individual preference of the operator. Some operators prefer a greater distance between condensers and film, even when operating at the above distance from the screen.

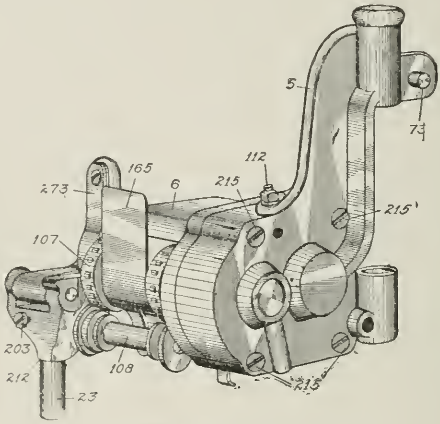


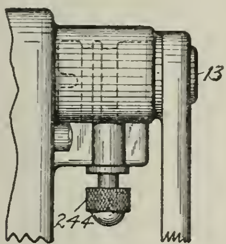
Fig. 51. Motiograph No. 2, 1908 and 1909 Framing Device

Motiograph Lens Adjustment. The lens should give a sharp focus on the screen giving clear detail. If the lens does not give a sharp focus after turning the focusing ring to both extremes of adjustment, it will be an indication that the extension collar used is either too long or not long enough, in which case test may be made by unscrewing the lens from the collar and holding it by the hand, shifting to different distances from the film to determine what position is necessary to give a sharp focus. The use of mica with scratches on it for the test focusing is recommended.

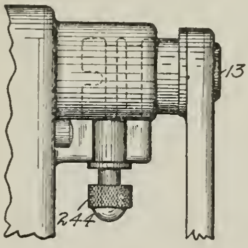
Open the film gate, swing it to the left, turn the crank of the motion-picture machine so the leaves of the shutter do not cover the opening in the aperture plate, so as to allow a free passage for the light through the aperture plate and the objective lens. This should be done before the film is placed in the machine.

The objective lens on the front of the motion-picture machine should now be focused by turning the focusing ring until the square of light on the screen is sharply defined: that is, the margin of the light opening should be clean and sharp and not fuzzy. When this is done only a slight adjustment is required to focus the picture sharply when the film is in place. All of the above adjustments should be accomplished before the film is placed on the machine. Some operators use a piece of mica on which some sharp scratches have been made with a knife, for the purpose of getting a sharp focus before the film is put in place. A piece of ruled mica is furnished with each Motiograph.

When using the Motiograph equipped with the automatic fire shutter, it will be necessary to open the film gate when doing the preliminary focusing of the objective lens, and to see that the illumination on the screen shows a clear outline of the margin of the aperture plate.



Position of Crank of Motiograph When Showing Pictures



Position of Crank of Motiograph When Rewinding Films

Fig. 52.

Threading the Film. When film is received from the manufacturers wound in a roll, the center of which is too small to admit the core block of the reel, it is necessary to rewind it. This may be done by removing the lower reel from the arbor, place the roll of film on the bare arbor, insert the outer end of the film under the spring clip on the core block of the upper reel, and wind the film on the upper reel.

To shift the connection between the crank and the reel arbor when using the Model No. 1 for 1909 or No. 1A for 1910, all that is necessary is to press a spring plunger at the right of the crank boss of the main frame, Fig. 52, turn the crank slightly, pull it toward you about $\frac{3}{16}$ of an inch, and the spring bolt will automatically drop into the other groove and hold the crank in place for rewinding the film, Fig. 53.

After the film has been wound on the upper reel, remove the upper reel and place it on the take-up below. Place another reel on the upper reel arm, take the outer end of the film (which was on the inside of the roll when received), pass it to the rear of the upper reel, inserting the end under the spring clip, and again wind the film on the top reel, making sure that the emulsion or dull side of the film is wound toward the outside.

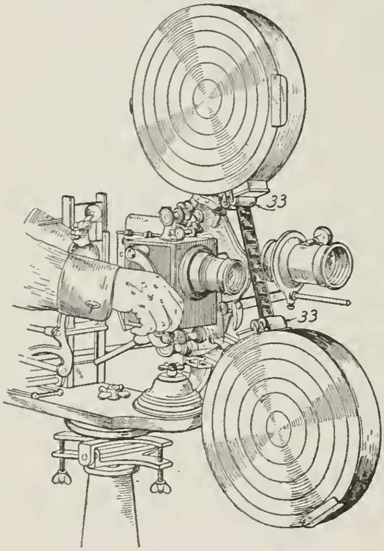


Fig. 53. Motiograph Rewinding

When the film has been wound back on the upper reel, press the spring plunger and return the crank to its normal position. When using this form of reeling mechanism in combination with fireproof film magazines, it is unnecessary to remove either the magazines or the reels for rewinding; in fact, with reasonable care and by the use of a few feet of white undeveloped film on each end of the picture film as leaders, the operator will see that the film is nearing the end, and it can be run and rewound time after time and it will not be necessary to disconnect the film from either reel until the film is to be changed for a different subject.

Draw from the reel a length of about 2 feet of film, press the handle of the upper sprocket roller bracket *24* to the left as far as it will go, pass the film under the sprocket wheel, so that the teeth of the wheel engage in the perforations of the film, and press the top of the roller bracket to the right until the roller comes into place against the sprocket wheel and holds the film in place. The roller brackets should not press tightly against the film, and there should be just room enough between the roller and the sprocket wheel for the film to pass without being pressed. The adjustment of these rollers is accomplished with the screw *203* and check nut. This adjustment is always properly set before the machines leave the factory, and should not require any further attention until the rollers have become somewhat worn, unless some one tampers with the machine. However, it is well to keep this adjustment in mind.

Press the film gate latch *154* to open the gate, swing the gate back, raise the intermittent sprocket roller bracket *23* until it stands in a horizontal position, lay the film on the aperture plate in such a position as to leave a loop at the top, as indicated by the word "loop," and return the intermittent roller bracket to its original position, to hold the film in place on the sprocket teeth of the intermittent sprocket.

The intermittent roller bracket has a screw adjustment the same as those of the upper and lower roller brackets, except that it has a check screw instead of a check nut to hold the adjustment.

Press downward on the handle of the lower roller bracket, pass the film over the lower feeding sprocket wheel, leaving a loop between the intermittent and the feeding sprocket as indicated by the word "loop" in Fig. 48. See that the teeth engage the sprocket holes in the film and turn the roller bracket to place. Pass the loose end of the film over the core block of the lower take-up reel and under the end of the spring clip.

When threading the film, place the framing lever about the middle of the two extremes of its up and down movement, for by so doing the upper and lower loops may be properly proportioned so as not to require rearrangement.

Turn the handle of the machine over to the right toward the front of the machine at the rate of about one revolution per second. The exact speed at which the handle should be turned will readily be determined by the movements of the figures in the pictures, which should be normal and natural, and by the flicker, which must not be too great.

While the machine is in motion test both bottom and top loop to see that they are sufficiently long. Take hold of the framing lever handle *75*, swing it up and down (while the machine is in motion only) as far as it will go, and when at the two extreme positions there should still be a small loop remaining. If the loop is entirely taken up, the roller bracket should be opened and the loop extended sufficiently. If this is not done the film may be torn. You are now ready to start. The loops should not be too long as they have a tendency to vibrate considerably, which may make the pictures unsteady.

It is important when running new film to scrape off the spots of film emulsion that collect on the film tension springs and the ribs of the aperture plate. These accumulations, if allowed to remain, have a tendency to not only scratch the film, but make it run unsteady, and are liable to be the cause of slightly tearing the corners of the sprocket holes in the film, besides making the machine run heavy, with increased wear to the parts. A silver dime is a good instrument to use for scraping them. On the first run film, the tension springs should be scraped before starting to make each run of a thousand feet. Do not scrape the springs with a knife or other steel instrument, as it would be liable to leave a rough surface on the tension parts that would injure the film.

Instructions. *To remove the front of the Motiograph* loosen the two thumb screws at the bottom, lift up the spring at the top while pulling the front plate forward sufficiently to disengage the spring, and lift it up to disengage it from the thumb screws below.

Adjustments. There are four important adjustments in the Motiograph that it will be necessary for the operator to concern himself with.

(1) The adjustment of the idler on the take-up belt should be just tight enough to make sure that the film will be wound up on the reel as fast as it comes through the machine. If too tight it will pull too hard on the film, with the result that it is liable to tear the sprocket holes. The flexible broad flat belt, in combination with the adjustable idler, furnishes a most sensitive, yet positive, means of taking up the film without doing injury to it. When the idler is adjusted, the check nut on the screw should always be tightened so as to retain the adjustment. If the belt is too tight when the tension is off, stretch it by pressing the two sides together near the large pulley.

(2) The adjustment of the sprocket rollers or idlers should be given careful attention. There should be just room enough for the film to pass freely between the roller and the sprocket without pressure on the film. The film rollers are adjusted to position by a set screw that passes through the roller bracket. After the screw is

THE BULLY GETS INTO TROUBLE

Scene from Photoplay, "On the Desert's Edge"

HE IS THE MAN

Scene from Photoplay, "A Half Breed s Courage"
Courtesy of the *Champion Film Company, New York*

properly adjusted the check nut or check screw, as the case may be, should be tightened so as to retain the adjustment.

(3) The Geneva movement that operates the intermittent film sprocket wheel, called the *star and cam,* will need to be adjusted only after it is worn to such an extent that the intermittent sprocket wheel can be slightly turned when at rest; that is, when the pin in the Geneva driver or pin wheel is on the opposite side of the pin wheel from the star wheel. The adjustment is accomplished by the two set screws that clamp the eccentric bushing in position. To set the Geneva parts closer together, loosen the lower set screw very slightly and tighten the upper screw. Have the adjustment of the Geneva driver, cam, or pin wheel just close enough to the star wheel

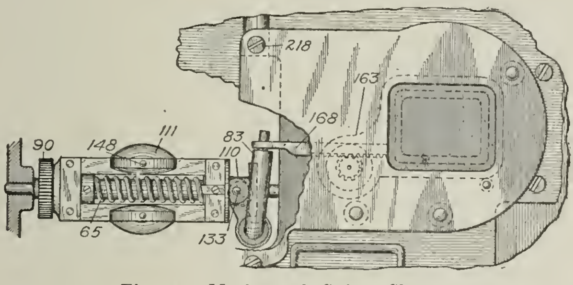


Fig. 54. Motiograph Safety Shutter

that the movement of the pin wheel shaft will be free and easy, yet so there will be no circular movement to the intermittent sprocket wheel while it is at rest. Do not tighten so the cam or pin wheel will not work perfectly freely.

The governor that operates the fireproof shutter may be removed from the Motiograph if necessary by removing the bushings at each end of the governor shaft or arbor, or by removing the gear bridge and the inside bushing. The bushings are held in place by set screws.

(4) The adjustment of the governor and fireproof shutter, Fig. 54, is accomplished by sliding endwise the pivot bushings in the frame. To adjust, loosen the screws that hold both bushings, hold the two between the thumb and finger and slide them slightly out and in when the machine is running at regular speed, until the point is reached where the fireproof shutter will be raised clear up, and at the same time, the little bar which connects the shutter with the governor crank bar will rest loosely on the governor crank pivot.

In no instance should it be drawn tight. Now tighten the screw on the inside bushing, then loosen the outside bushing just enough so the governor will work freely, and tighten the screw on that bushing.

Don't adjust the governor too tight; if too tight, the machine will run hard and, besides, the wear will be excessive.

Oiling. It is absolutely necessary that a motion-picture machine be kept well oiled, in order to keep it in good condition, and that it may do good work. Remember that while in operation the balance wheel shaft and Geneva action, which operates the intermittent sprocket, is making nearly 1,200 revolutions per minute, or 72,000 revolutions per hour, and that when giving fifteen shows per day, of twenty minutes each, the balance wheel and Geneva action has made 360,000 revolutions. No machine can be expected to endure such work without proper care. Be sure that *all* of the bearings are oiled and that none have been overlooked.

When running afternoon and evening all of the bearings should be oiled twice during the day, besides which the Geneva movement and governor shaft pivots should be oiled after every other show, or make sure that there is a sufficient amount of oil in the Geneva movement casing, that the Geneva movement is kept constantly lubricated.

It is important that the oiling should be carefully done, and that none of the bearings should be overlooked. It is advisable to establish a practice of always oiling the bearings in the same order, as in this way you will be less liable to overlook any of them. Care should be exercised not to have any oil on the sprocket wheels and on the film pressure rollers, as oil in these places would be transmitted to the film and badly damage it. All surplus oil remaining on the outside of the oil holes, or in other places where it might come in contact with the film, should be carefully removed with a soft cotton cloth.

The quality of oil used on a motion-picture machine is of great importance. Do not get the impression that anything sold under the name of oil is good enough. Never oil with kerosene or any oil that is highly adulterated with kerosene, as it has practically no lubricating properties. Do not use ordinary lard oil that is adapted to use on heavy machinery; it is too coarse and will gum the bearings.

There are oils on the market, some of which are extensively advertised and are recommended for lubricating, polishing furniture, and as rust preventives, etc., that are not at all suitable for the lubrication of a motion-picture machine. Sewing-machine oil of fine grade is most desirable, and the best place to get it is at a sewing-machine agency. A cheap grade of sewing-machine oil should not be used owing to its poor quality as a lubricant.

Vaseline is used in the framing device oil chamber. Remove that part of the framing device which forms the cover to the oil chamber by removing the four screws in the side. Take the remaining part of the framing device in one hand, and with the flexible metal tube of white vaseline in the other, force the vaseline into the opening of the flange of the pin wheel, where the pin is located until that opening is well filled, then force the vaseline all around the outside of the flange of the pin wheel. Then cover the entire surface of the star with a liberal coating. This is all that will be required. Care must be taken not to put in too much vaseline, as the rapid rotation of the star and cam wheel will have a tendency to force it out through the oil cup, which would be very undesirable.

After replacing the cover put eight or ten drops of fine lubricating oil in the oil cup on top of the framing device, which will mix with the vaseline and soften it to the proper consistency. If care has been taken in applying the vaseline thoroughly the machine should run, even under the heaviest usage, for at least three weeks without further attention to this part, except to add occasionally a few drops of fresh oil. At the end of that period, if the vaseline has become blackened, it is time to remove it, clean the pin and star wheel, wash them off with benzine or gasoline and put in fresh vaseline as described above.

Vaseline is used as a lubricant for the star and pin wheel and is without an equal for the Motiograph. It is necessary, however, to avoid the cheap qualities put up in bulk, and never, under any circumstances, use carbolated vaseline. Use the white vaseline put up in flexible metal tubes, which may be had at drug stores or it may be ordered of the manufacturers of the Motiograph.

When oil only is used without vaseline it is preferable to use a very heavy oil of fine quality, rather than a thin oil.

To keep a machine in good condition it should occasionally have the working parts cleaned with gasoline to remove dirt, gum, and old oil, the parts wiped dry with a soft cotton cloth, and fresh oil applied.

The high-speed spindles of the Motiograph all run in interchangeable phosphor-bronze bearings. These may be replaced with new ones when worn. Phosphor-bronze is one of the best anti-friction metals known, and with proper care none of the bearings should need replacing for a long time.

The fire-trap rollers should be kept clean. In case the film should become ignited and the flame extend to the fire trap or valve, some of the melted celluloid is liable to stick to the rollers and when dry it becomes very hard and brittle and would do much damage to the film if allowed to remain. In a case of this kind the rollers should be carefully cleaned. The rollers should also be cleaned from time to time to keep them free from accumulations of dust, oil, etc., which will do more or less injury to the film. Alcohol or refined benzine is good for the purpose.

The belt idler adjustment screw is provided with two check nuts, the purpose of which is that when the desired adjustment has been secured, one nut may be locked against the other, in order that the screw together with the nuts locked in position on the screw, may be loosened while the film is being rewound, as otherwise the pull would be too heavy on the film if the tension was allowed to remain the same as when the film is being taken up on the rewind. After rewinding, the adjustment screw may be instantly returned to its former position.

If, for any reason, it should become necessary to remove the gear bridge of the 1908 or 1909 models, the disconnecting of the gears would throw the shutter out of time until the shutters are reset—that is, the wings of the shutter would not cut off the light at the proper moment with relation to the movement of the film, the result of which would be to show a ghost, especially on the announcements. This would not occur with the 1910 No. 1A model. The shutter might also be thrown out of time from coming in contact with something inserted within the frame while the shutter is in motion.

Setting the Motiograph Shutters. *Setting the Intermittent Double No. 1 Cone Shutters on the No. 1A Motiograph, Model 1910,* Fig. 55. The instructions for setting the double shutters of the No. 1A Motiograph for 1910 are different from the instructions for the shutters of the No. 1 Models, 1908 and 1909. The reason for the difference is that in the 1908 and 1909 Models the movement of the shutters is in the opposite direction to those of the 1910 Model.

The principle of setting the shutters for the Motiograph is the same as for any other moving-picture machine, that is, the larger wings of the shutters should cover the light opening or aperture during the time that the intermittent sprocket and film are in motion, and the smaller wings should pass during the exposure while the film is at rest, Figs. 56 and 57.

To set the shutters, remove the front plate, which carries the lens, after which remove the outer shutter wing (the one nearest you),

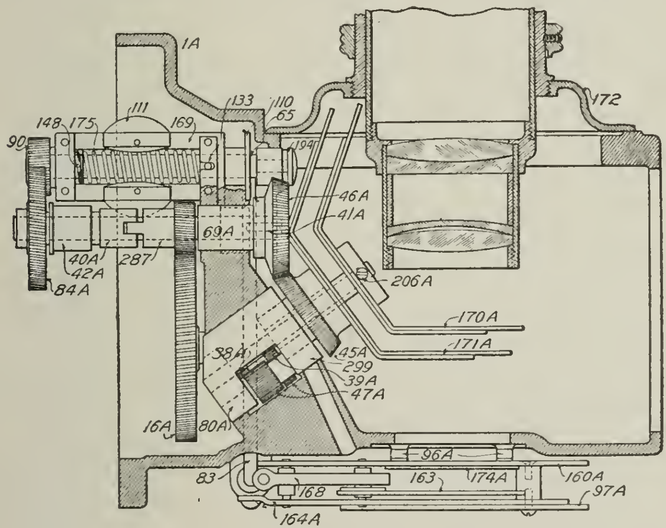


Fig. 55. Sectional View of the Intermittent Shutter Arrangement of the Model No. 1A, 1910 Motiograph

loosen the screws on the inner shutter, leaving the shutter just loose enough to be turned easily by hand, and tight enough so it will not move of its own accord. Remove the gear cover, after which take hold of the balance wheel and turn the mechanism in the same direction as during the operation of the machine; turn very slowly until the intermittent sprocket wheel starts to move, after which set the upper edge of the large wing of the inner shutter about 1/16 inch below the center of the aperture plate when looking on a line parallel through the center of the light aperture. These measurements refer to the 36-degree shutters. Now revolve the mechanism slowly in the same direction, observing when the intermittent sprocket wheel stops that the lower edge of the large wing of the inner shutter is about 1/16 inch above the center of the aperture plate.

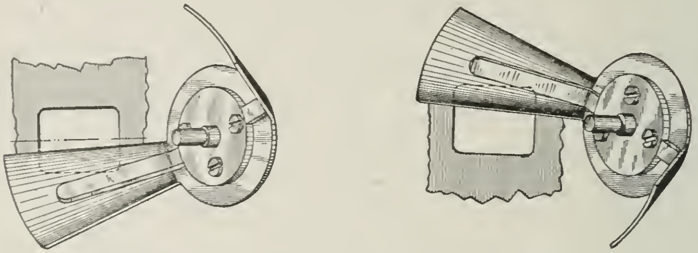


Fig. 56. Fig. 57.
Motiograph Shutter in Two Positions

Tighten the screws firmly, after which revolve the mechanism until the inner shutter is at the original position, that is, the upper edge of the large wing should be about 1/16 inch below the center of the aperture plate. Replace the outer shutter on the shaft, tighten the screws partially in the same manner as was done with the inner

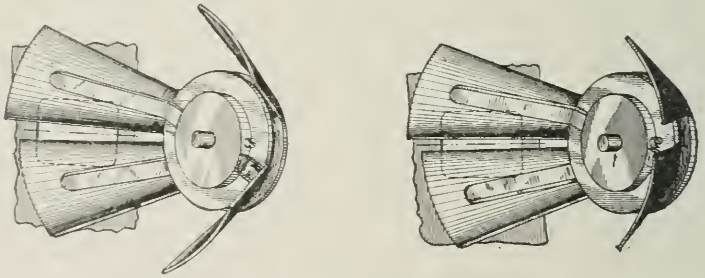


Fig. 58. Fig 59.
Motiograph Double Shutter in Two Positions of Adjustment

shutter, set the lower edge of the large wing about 1/16 inch above the center of the aperture plate, after which tighten the screws firmly, Figs. 58 and 59.

After the setting of the shutters has been once done, it will be very simple and easy to repeat.

The width of the shutter wings that will be furnished, unless otherwise ordered, will be that known as the 36-degree wings, which are best adapted to distances from 60 to 100 feet or more. The 36-degree wings are narrower than the 42-degree wings and give the greatest possible amount of exposure as compared with the non-exposure. On distances less than 60 feet, and especially where brilliantly-colored announcements are used, such as a brilliant red, there is liable to be a slight ghost of color above and below the announcement. Also where there are plain whites in the picture, with heavy backgrounds around them, there is liable to be a slight ghost.

These defects being so slight are, to most exhibitors, not objectionable in view of the advantage of a greater amount of exposure, but where they are, they may be entirely overcome by use of the 42-degree shutters, the wings of which are wider than the 32-degree.

To Set the No. 2 Motiograph Shutter. Remove front plate which carries lens, loosen screws in shutter just enough so shutter can be easily turned on the shaft. Take hold of the balance wheel, revolve mechanism in same direction as during operation of the machine, observe when the intermittent sprocket starts to move and set lower edge of shutter at bottom edge of aperture. Turn the balance wheel until the sprocket stops, at which time the top edge of shutter should be on a line with the top edge of the aperture. When properly set, tighten the screws in shutter.

Lenses of shorter focus than about 2¾ inch cannot be used to advantage with the regular Motiograph double or single cone shutters, and when lenses of shorter focus than about 2¾ inch are to be used, we recommend the use of the *Auxiliary front intermittent shutter No. 3,* which may be attached to and used with the No. 1A mechanism, the first of which were placed on the market in April, 1910. With this form of shutter there is no limit and lenses of as short focus as may be desired can be used. Extreme short focus lenses should never be used where the machine could be set at a point where longer focus lenses can be used, and especially where the machine is to be located considerably above or below a line that would be parallel with the center of the screen, because at best, an extreme short focus lens requires the greatest possible care in focusing and when located at a considerable distance above or below a line that would be parallel with the center of the screen, it will not be practicable to get a sharp focus on all parts of the picture.

To Attach the Auxiliary Front Intermittent Shutter No. 3. The auxiliary front intermittent shutter No. 3 is used in front of the lens. It is mounted on a front plate, which is to be used in place of the regular front plate that comes with the Motiograph Model No. 1A. On the shutter shaft is a beveled pinion and for connection with this pinion is a second beveled pinion, which is furnished with the shutter and front plate. This second beveled pinion is to be attached to the shutter drive shaft on the inside of the mechanism, by first removing the larger beveled gear that is attached to the shutter drive shaft. These beveled gears are held on the shutter drive shaft by a single screw. There is a steel plate attached to the center of the gear, on which there is a tongue which engages with a groove of the same size in the shutter drive shaft. Care should be exercised that the tongue is properly engaged with the groove in the shaft before

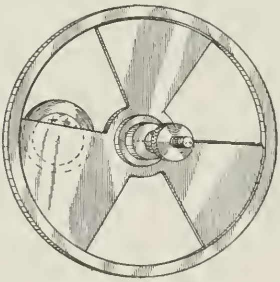


Fig. 60

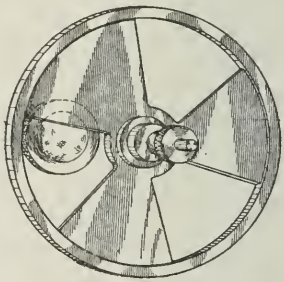


Fig. 61

Before the Lens Shutter in Two Positions of Adjustment

tightening the screw. When using the front shutter, the wings of the regular cone shutters, No. 1 and No. 2, should be removed.

To Set the No. 3 Shutter. Place the shutter on the shutter shaft, as shown in Fig. 55. It is held in place on the shaft by a thumb nut on the end of the hub. The shutter consists of three wings, one of which is larger than the other two. The large wing is intended to cut off the light while the film is in motion and the other two serve as interrupters for the reduction of flicker. To set the shutter in time with the intermittent film sprocket, loosen the thumb nut on the hub of the shutter, take hold of the balance wheel and turn the mechanism very slowly in the same direction as when in operation until the intermittent sprocket begins to move. Set the top edge of the large wing so it is about $\frac{1}{4}$ of an inch above the center of the lens, Figs. 60 and 61. Now turn the balance wheel until the intermittent sprocket stops, then see that the lower edge of the large wing of the shutter is about $\frac{1}{4}$ of an inch above the center of the lens. The shutter should be set as far back on the shaft as is practicable, that is, not to exceed about $\frac{1}{2}$ inch from the front of the lens mount. When properly located tighten the thumb nut on the shutter hub. When long focus lenses are to be used, the shutter may be reversed on the shaft, that is, the hub and thumb nut placed at the rear. This will make it possible to set the shutter well to the front, so as to pass in front of a long focus lens.

When using alternating current of 60 cycles, two interrupters may be objectionable, owing to the fact that at times the alternation of the current is liable to run synchronously with the interrupters in the shutter in such a way as to very largely cut down the illumination. Where this condition exists, the only remedy is to use a shutter having but one interrupter.

INDEX OF PARTS FOR THE MECHANISM OF THE NO. 1A MOTIOGRAPH MODEL 1910, FIGS. 62 TO 67 INCLUSIVE

1A	Main frame of mechanism
2A	Base
3A	Gear cover
3½A	Gear cover for motor pulley and idler
4A	Bridge
05A	Framing device (vertical part)
06	Framing device (horizontal part)
7A	Upper reel arm—casting only
8	Upper reel arm cap
9A	Lower reel arm
10	Arm idler tension
11A	Framing lever
12A	Main clamp thumb wheel and screw
13A	Crank without handle
013A	Crank handle complete
14	Balance wheel
15A	Main gear
16A	Gear and pinion between crank shaft and balance wheel pinion
17A	Gear on lower sprocket shaft
18A	Gear between balance wheel shaft and lower sprocket shaft
19	Governor crank complete
20	Small belt pulley and screw
21	Large belt pulley and screw
22	Lens mount ring
23	Intermittent roller bracket
24	Roller bracket, top, with arbors
25	Roller bracket, bottom
26	Spider for fireproof magazine
028	Bushing for intermittent sprocket arbor
29	Magazine latch, large piece
30	Magazine latch, small piece

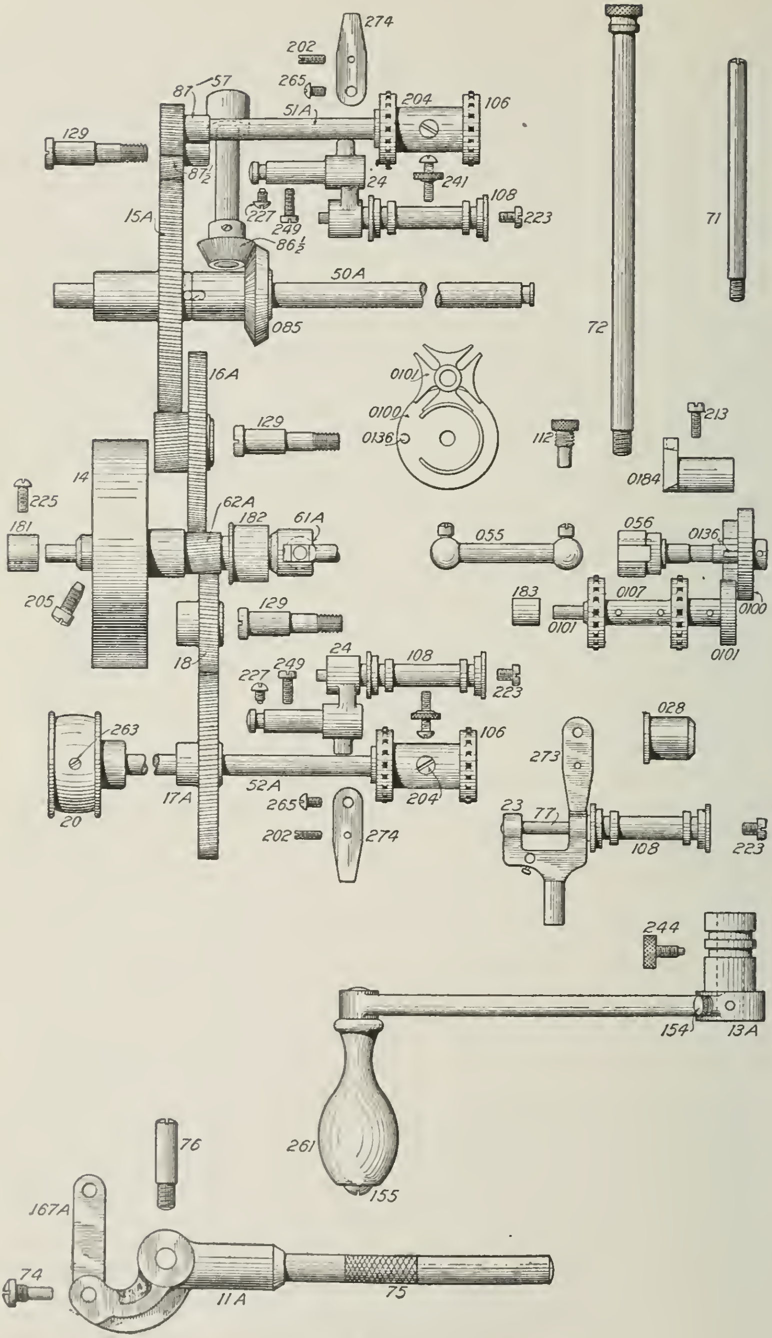


Fig. 62. Motiograph Par s

31-32	Magazine hinge	71	Framing device guide rod
33	Fire trap, casting only	72	Framing device slide rod and head
33ct	Fire trap, complete with rollers	74	Framing lever joint screw
37	Lens arm bracket	75	Framing lever handle
38A	Shutter arbor and pinion, solid	76	Framing lever fulcrum screw
39A	Shutter arbor and pinion, main, hollow	77	Intermittent roller bracket joint pin
40A	Governor drive shaft	80A	Bushing for gear case (rear)
41A	Shutter drive shaft screw	83	Governor crank arbor
42A	Bushing for governor drive	84A	Gear on governor drive shaft
43A	Screw for intermittent sprocket	085	Bevel gear on crank arbor
44A	Screw for gear on upper sprocket arbor	86	Bevel pinion on upper reel arm arbor
45A	Bevel gear on shutter drive shaft	86½	Bevel pinion on rewind socket arbor
46A	Bevel gear on shutter shaft	87	Gear on upper sprocket arbor
47A	Intermediate pinions in gear case	87½	Intermediate gears, small
48A	Screw for clamping shutter wing	89	Bevel gear on reel arm vertical arbor
50A	Crank arbor with pin	90	Gear on governor arbor, and hub
51A	Upper sprocket arbor	91	Stereopticon slide rod
52A	Lower sprocket arbor	91½	Stereopticon slide rod, nut, and washer
055	Ball arbor	92A	Screw to locate gear case
056	Knuckle joint socket on Geneva arbor	93A	Screw to retain gear case
57	Reel arm socket arbor	94	Push rod for reel arm
58	Reel arm vertical arbor	95	Locking pin for rewind shift
59A	Reel arbor, upper	96A	Film tension jaws, each
60A	Reel arbor, lower	97A	Heat arrester gate
61A	Balance wheel arbor and socket	99A	Thumb screw for front plate
62A	Balance pinion and sleeve	0100	Geneva driver and arbor, complete
63	Upper fire shield	0101	Intermittent sprocket arbor and star
64	Lower fire shield	102	Screw for eccentric bushing, framing device
65	Governor arbor	103A	Screw to retain shutter drive bushing
65G.C.	Governor complete	105A	Cap for hole in foot of main frame
69A	Bushing for shutter drive arbor		

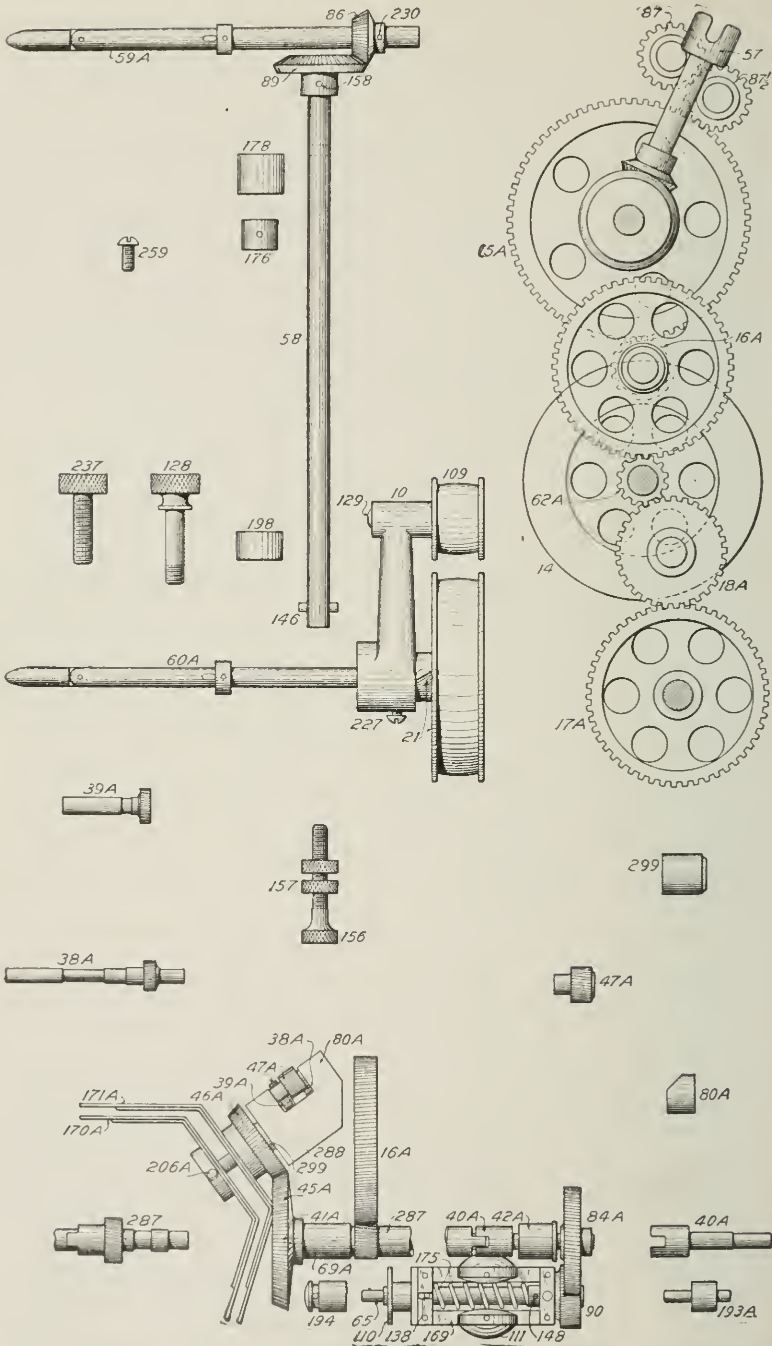


Fig. 63. Motiograph Parts

106	Sprocket, upper or lower
0107	Intermittent sprocket
108	Film rolls
109	Idler pulley
110	Roller guide on governor shaft
111	Governor balls
112	Oil cup
114A	Gear casing for shutter, complete with gears
116	Roller, top of door (2 rolls and shaft)
117A	Locating plunger for crank handle
118A	Spring for locating plunger
119	Center pin in hinge of fire magazine
120A	Side plate
123	Collar on door latch rod
125	Door latch rod
126	Door roller pin
127	Ball screw and door hinge
128	Screw for upper and lower reel arm
129	Screws for gear and idler
133	Pin in governor arbor
135	Pin for motor drive
0136	Pin in Geneva driver
146	Pin reel arm vertical arbor
148	Pin in gear on governor arbor
154	Screw in crank
155	Screw in handle of crank
156	Adjusting screw on take-up idler
157	Check nut on take-up idler
158	Pin in vertical reel arbor gear
160A	Door plate
162A	Aperture plate
163	Brass shutter and pinion
164A	Heat arrester
165	Stripper plate
167A	Connecting bar for framing device
168	Rack for fire shutters
169	Governor strips, each
170A	Shutter wing (outer) with collet and screws
171A	Shutter wing (inner) with collet and screws
172·	Front plate
174A	Film tension spring
175	Governor springs
176	Collar on reel arm vertical arbor
178	Large bushing vertical reel arbor
181	Bushing for balance wheel arbor, small
182	Bushing for balance wheel arbor, large
183	Small bushing for intermittent sprocket shaft
0184	Eccentric bushing for framing device
193A	Bushing in bridge for governor shaft
194	Bushing in frame for governor shaft
198	Bushings in reel arm (small)
200	Screw in governor crank
202	Locating screw for idler bracket spring
203	Screw for Nos. 23, 24, 25
204	Screws for sprockets, upper and lower
205	Screw for balance wheel
206A	Screws for shutter collet
207	Screws for upper reel arm cap
208	Locating screw for front plate
209	Screws to fasten magazines to spiders
210	Screws for spring on framing device

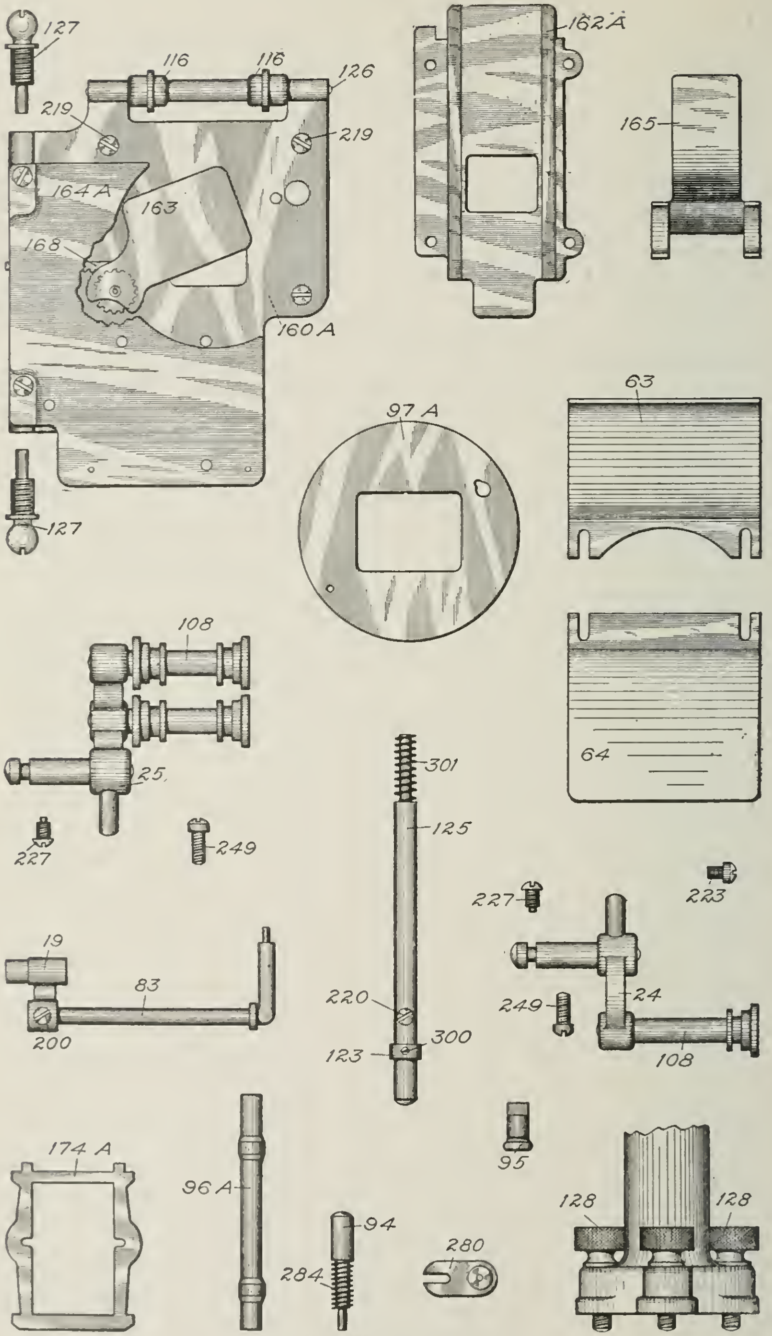


Fig. 64. Motiograph Parts

211 Screws for stripper plate
213 Screws for small bushing, framing device
214 Screws for large bushing, framing device
215 Screws for framing device cap
224A Screws for bridge
225 Screws for bushing in bridge
227 Locating screw for idler tension arm
228 Screw for bushing in governor shaft

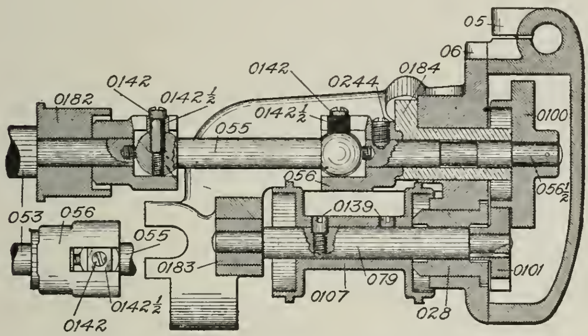


Fig. 65. Motiograph Framing Device Parts Assembled

216 Screws for friction on vertical rod
217 Screws for aperture plate
218 Screws for fire shields
219 Screws for studs on door
230 Screw in reel arbor bevel pinion
231 Upper screw for gear cover
232 Left side screw for gear cover
233 Right side screw for gear cover

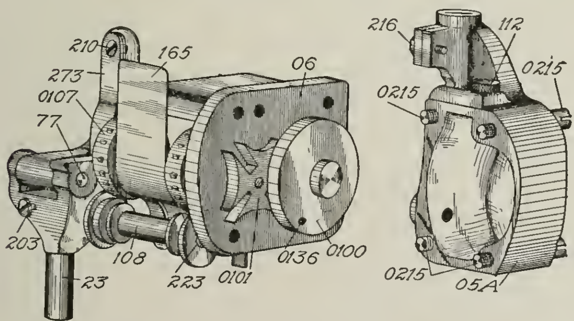


Fig. 66. Parts for No. 2 Motiograph Mechanism

220 Screws for door latch
221 Screws for tension springs
222 Screws for stop on door
223 Screws for roller arbors
235 Screw for holding bushing in frame
237 Screw for attaching magazine to reel arm

238 Magazine body and cover
241 Check nut on roller bracket
244 Screw for locating crank-handle
245 Set screw in socket arbor
246 Screw in roller bracket
248 Safety cap for crank arbor
249 Screw to hold roller bracket in place
251 Roller for fire trap, plain
252 Roller for fire trap, with flange
253 Pins for roller arbor
254 Tension plunger in fire trap
255 Screws to hold traps to magazines
256 Screws for fire trap
257 Screws for nut on reel arbor
258 Spring for pressure rollers in fire trap
258½ Spring for gate latch
259 Set screw to bind bushing in reel arm
261 Wood handle for crank
262 Screws to check guide rod
263 Screws for small belt pulley
265 Screws for roller bracket springs
267 Screws for framing device bushing
268 Screws in magazine latch
273 Springs for framing device (2 pieces)
274 Springs for roller bracket (3 pieces)
275 Springs for front plate (2 pieces)
276 Set screw for large bushing on balance arbor
277 Take-up belt
284 Spring for push rod
285 Balance arbor screw
286 Motor drive arbor
287 Shutter drive arbor and pinion
288 Gear case
289 Screws for bushing in gear cases
290 Arbors for intermediate gears in gear case
291 Screw in gear on lower sprocket arbor
292 Adjusting screw for eccentric bushing in framing device
293 Screw for socket Geneva arbor
294 Screw for upper fire shield
295 Latch pin for side plate
296 Nut for latch pin
297 Spring for latch pin
298 Screws for side plate
299 Bushing for gear case (front)

MOTIOGRAPH No. 1A ARC LAMP

MG 1 Burner slide
MG 1¼ Machine screws
MG 3 Main body
MG 3¾ Main body stud to hold upper castings
MG 4 Lower horizontal casting
MG 4¼ Stud
MG 4½ Lower horizontal casting stud
MG 4¾ Roller
MG 5 Upper horizontal casting
MG 5½ Upper horizontal casting stud
MG 9 Carbon clamp, complete; long (1)
MG10 Carbon clamp, short
MG11 Upper carbon clamp bracket
MG12 Upper rack bracket
MG16 Lower carbon clamp bracket
MG17 Lower rack bracket

THE BARRICADE
Scene from Photoplay, "General Meade's Fighting Days"

SCENE FROM PHOTOPLAY, "HEARTS AND FLAGS"
Courtesy of *Thomas A. Edison, Inc., Orange, N. J.*

MG18 Upper rack
MG19 Lower rack
MG20 Screw for lower horizontal casting
MG22 Rack plate
MG22½ Screws
MG23 Rack pinion and arbor
MG24 Rack pinion ball, joint and pin
MG24 Rack pinion ball screw
MG25 Shaft to operate racks, complete

MG39½ Swivel screw for up and down adjustment
MG40 Socket
MG40½ Ball joint screw
MG40¾ Pin
MG41 Shaft for up and down adjustment, complete
MG46 Wood handle on up and down adjustment
MG46½ Screw for wood handle
MG47 Plate on lower carbon clamp

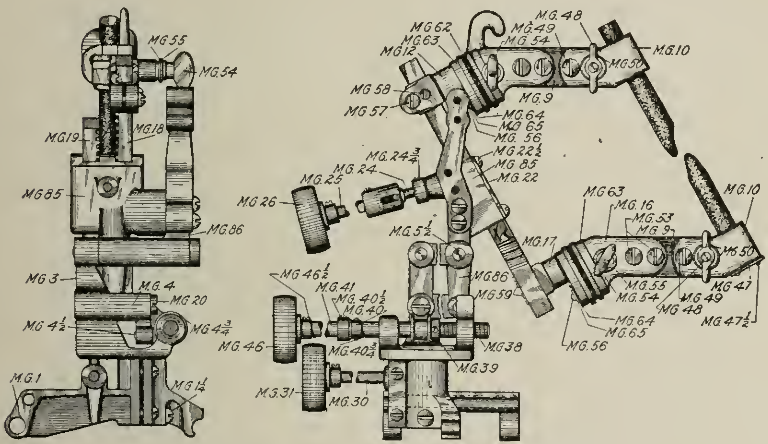


Fig. 67. Parts for Motiograph No. 1A Arc Lamp

MG26 Wood handle for shaft racks
MG26½ Screws for wood handle, rack shaft
MG30 Shaft for side adjustment, complete
MG31 Wood handle, side adjustment
MG31½ Screw for wood handle
MG32 Swivel collar for side adjustment
MG33 Screw to hold swivel collar
MG34 Washer on side adjustment shaft
MG38 Screw for up and down adjustment

MG39 Swivel for up and down adjustment
MG47½ Screws for plate
MG48 Wing nuts for carbon clamps (2) $\frac{1}{4} \times 24$
MG49 Machine screws to hold short clamps (2) 10×24
MG50 Washers for short carbon clamps
MG53 Machine screws to hold long clamp to bracket (4) $\frac{1}{4} \times 24$
MG54 Thumb screws to hold wire, (2)
MG55 Washers for No. 54 (4)

MG56 Machine screws to hold brackets
MG57 Machine screws to hold upper bracket on rack, (1) 10 × 24
MG58 Machine screws to hold upper rack on bracket (1) 8 × 32
MG59 Machine screws to hold lower rack on bracket (2) 8 × 32
MG62 Mica insulators—flat—set
MG63 Mica insulators round bushing
MG64 Mica insulators round washers
MG65 Iron washers for M.G. 56
MG75 Main body No. 2 and stud (for use on No. 2 Motio)
MG80 Shaft for No. 2 up and down adjustment, complete (for use on No. 2 Motio)
MG85 Rack body (new style)
MG86 Bracket for rack body (new style)

UPPER CARBON ADJUSTMENT FIXTURE

MG91 Rack bracket for adjustment fixture
MG92 Adjustment bracket for carbon clamp
MG93 Support bolt
MG94 Adjustment screw
MG95 Adjustment handle
MG96 Clamp bolt
MG97 Collar for adjustment screw
MG98 Stock washer $\frac{9}{16} \times \frac{3}{32}$ inch
MG99 Stock screw—round head, 8-32 × $\frac{1}{4}$ inch
MG100 Pin for collar for adjustment screw $\frac{3}{32} \times \frac{1}{2}$ inch
MG101 Headless screw for adjustment thumb nut

UPPER UNIVERSAL CARBON CLAMP

MG110 Bracket (long)
MG111 Clamp screw for bracket
MG112 Locating screw for bracket
MG113 Swivel for bracket
MG114 Clamp screws for swivel
MG115 Washers for clamp screws for swivel
MG116 Carbon holder
MG117 Wing nut for carbon holder

LOWER UNIVERSAL CARBON CLAMP

MG118 Bracket (long)
MG119 Clamp screw for bracket
MG120 Locating screw for bracket
MG121 Swivel for bracket
MG122 Clamp screw for swivel
MG123 Washers for clamp screws for swivel
MG124 Carbon holder
MG125 Wing nut for carbon holder
MG126 Stop plate on carbon holder
MG127 Screws for stop plate

POWER'S NO. 5 CAMERAGRAPH

The Power's No. 5 cameragraph is a projecting machine which has been well known for several years. The right side, or crank side,

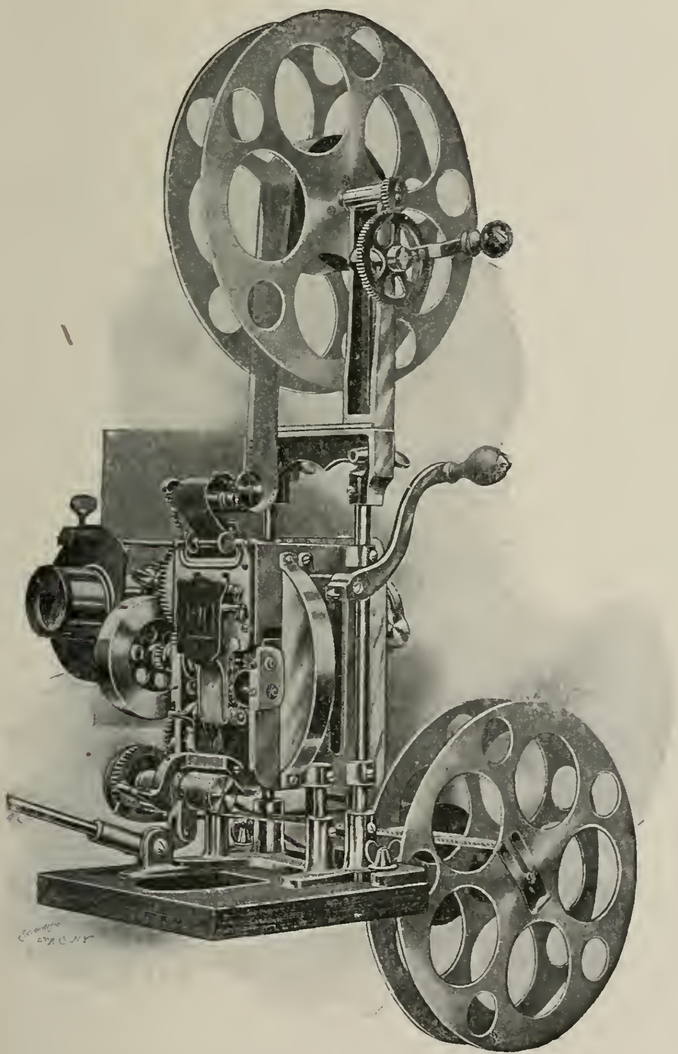


Fig. 68. Crank Side of Power's No. 5 Cameragraph

of the motion-head mechanism of the No. 5 model is shown in Fig. 68, while the reverse, or left side, is shown in Fig. 69. In the illustrations, the motion head is equipped with an upper reel hanger, holding an open reel for the feed reel of film, instead of the iron fire-

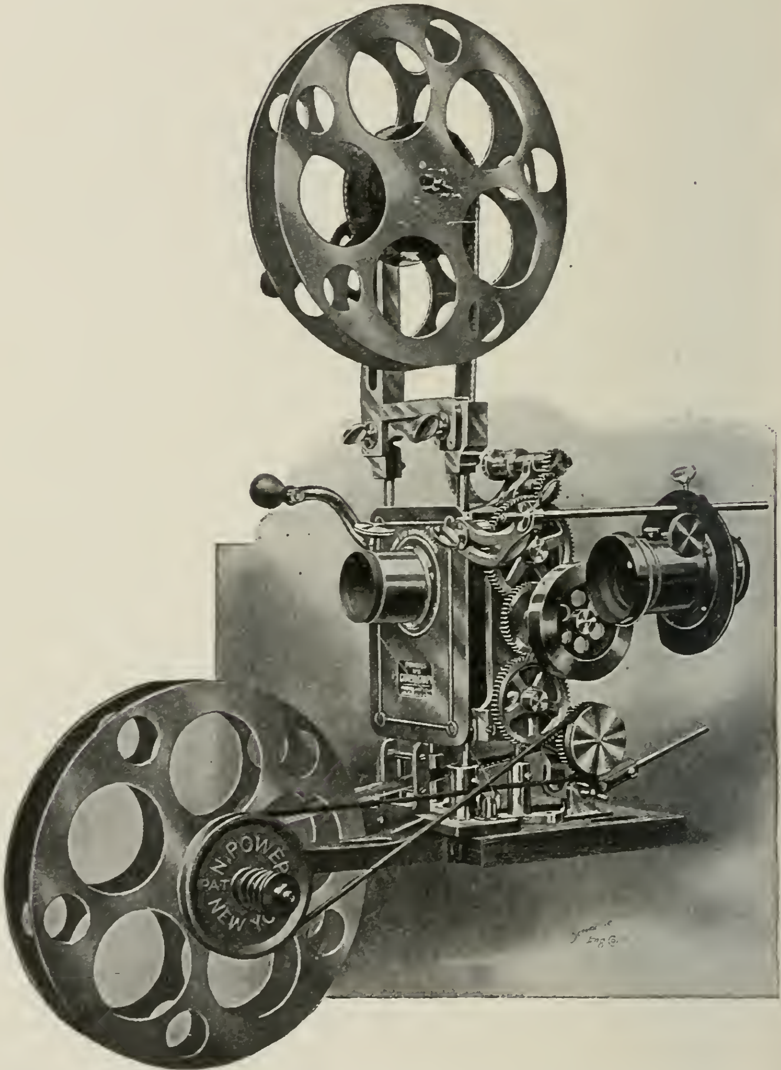


Fig. 69. Left Side of Power's No 6 Cameragraph

proof magazine. By the turning of two thumb screws, the upper reel hanger may be lifted off and the fireproof magazine hung in its place. This furnishes a convenience in packing, and in working about the motion head to clean it up before beginning the evening's run of the show.

The intermittent mechanism is the standard three-sprocket type, upper steady feed, intermittent sprocket at the film gate, and lower steady feed below. The intermittent (in the No. 5 mechanism) is driven by the Geneva form of drive, kept in balance by a heavy fly wheel mounted directly upon the pin shaft of the intermittent mechanism. The four-slot Geneva star and one-pin cam is used, and the mechanism is timed to about $\frac{1}{4}$ motion and $\frac{3}{4}$ rest for each picture.

The shutter of the No. 5 model is within the motion head, mounted very close to the film window. It projects near the crank handle of the motion head, and is covered by the curved shield seen near the handle in Fig. 68. The shutter is of the so-called "balanced" or multiple wing type, two wings being used, the broader one covering the aperture during the shift of the film and the narrower one being introduced to reduce the flicker.

The framing mechanism is a sliding carriage on the main body of the motion head; it carries the intermittent sprocket, the pin wheel, and the star wheel, and it is shifted by a short framing lever having a toggle joint with the carriage.

An ingenious arrangement of gearing is provided by which a constant meshed gear connection is maintained between the crank shaft—which is mounted rigidly in the main body of the motion head—and the Geneva movement, which is carried movably by the framing carriage. A spur gear on the main body and a spur gear on the pin-wheel shaft of the framing carriage have an idler spur wheel between them, the idler being hung upon a pair of movable arms which keep it at all times meshed with both of its meshing gears in the train.

The presser rollers by which the film is kept in engagement with the feed sprockets are all mounted in pivoted brackets, controlled by springs, and are provided with set screws by which the rollers may be adjusted to the sprockets to secure proper control of the film.

The aperture plate is provided with hardened steel guide strips on its face for guiding the film. On the film gate, in front of the film window, and on the lamp-house side, is a heavy plate called a "cooling" plate, apparently having no function in the operation of the machine, but its purpose is to prevent the rays of the lamp from shining directly upon the film gate and heating it to a high degree which would endanger the film.

The upper reel hanger is provided with a rewind handle, hence it is not necessary to detach the main drive handle or move it to a new position to rewind the film. The rewind handle does not engage

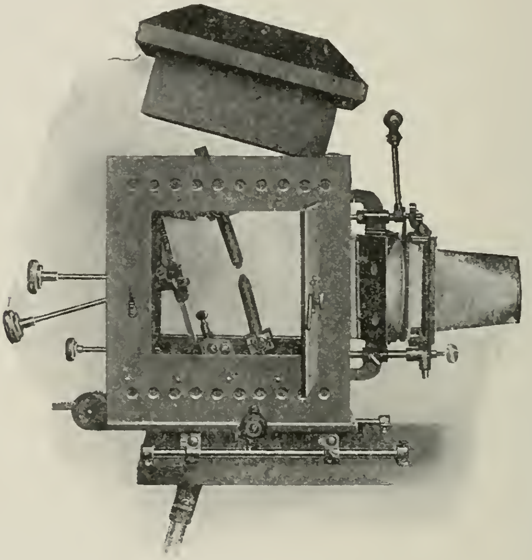


Fig. 70 Cameragraph Lamp House, No. 5 Model

the feed reel until pushed in upon its shaft, so it does not interfere with the turning of the feed reel during the unwinding of the film for projection.

The lamp house slides upon a double rod track to pass from the motion head to the stereo lens, or *vice versa,* and this double-rod cross track in turn slides upon a pair of rails or rods upon the projection table which enables the lamp house to be placed at any desired distance from the motion head and stereo lens, thus affording every facility for the projection operator to get his condensers and his lens into proper focal relation with each other. The lamp house and its double arrangement of cross tracks is shown in Fig. 70.

The lamp is a two-knob lamp, easy for the beginner to control during the projection of the pictures, because he is not likely to turn the wrong knob and throw out a carefully adjusted screen illumination. The lamp is shown in Fig. 71. The larger knob is the feed knob, by which the arc is struck and the carbons are fed down as they burn away during projection. The smaller knob is the tilting knob, by which the lamp frame of the lamp, including the feed rods, carbon clamps, and carbons, is tilted up or down, according as the

Fig. 71. Cameragraph Lamp, No. 5 Model

knob is turned, to bring the arc into proper center with the condensers. The proper distance of the arc from the condensers and the proper transverse or side adjustment of the lamp is made inside the lamp house, through the door. The height is made by the sliding block and set screw which clamps it to the vertical rod of Fig. 71, upon which the lamp frame is mounted. The distance from the condensers forward or back in the lamp house is made by moving the base of the vertical rod, in the house, but in some of these lamps there is a third knob projecting at the very bottom of the lamp house at the back, and the lamp may be slid toward or from the condensers by turning this extra knob, which is so low that it is not likely to be touched by accident during projection. The design of the Power's lamp and lamp house is such as to avoid accidental moving of parts which should be left alone during projection.

The top of the Power's lamp house is hinged, and may be swung upward to afford convenience in setting the carbons, the operator passing one hand through the top of the lamp house and the other through the door.

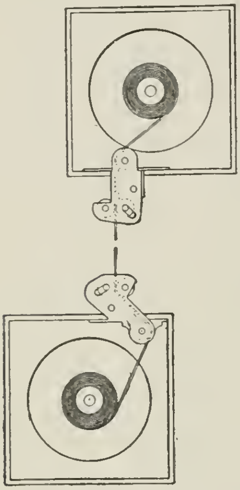


Fig. 72. Cameragraph Film Outlet and Fire Trap

The lamp house also has the douser shutter between the condenser and the lantern slide, instead of at the end of the condenser hood, thereby protecting the slide when not being projected.

The fireproof magazines for feed and take-up reels are provided with a special type of roller fire trap, shown in Fig. 72. It will be noticed that one of the rollers of the fire trap has its shaft projecting at both ends. In feeding the film end through the trap, the ends of this roller are caught with two fingers and the roller is slid back in its slots to permit the end of the film to pass.

The Power's machines are equipped with two styles of fire shutters. Style *A* is shown in Fig. 73. It is operated by an inward movement of the driving crank upon the shaft. The crank is set upon the shaft with a cam slot and a pin and spring, so that when the power is applied to turn it, it automatically moves inwardly to open the shutter. Style *B* is shown in Fig. 74. This shutter requires that the mechanism have a certain speed of revolution before the shutter will operate to open the film window to the light of the arc lamp, and it is operated by a centrifugal wheel geared to the film driving mechanism of the motion head. Upper and lower film shields are shown in Fig. 74. The lower shield is hinged at the bottom, to permit the operator to get at the mechanism for threading up the film.

Figs. 75 and 76 give illustrations of such parts of the Power's No. 5 Cameragraph as are likely to be needed for repairs, and identify them by number. In ordering a repair part, both name and number should be given.

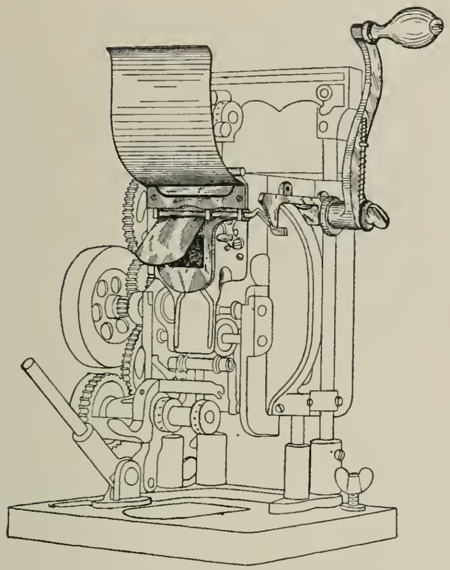


Fig. 73. Cameragraph Safety Shutters, Style A

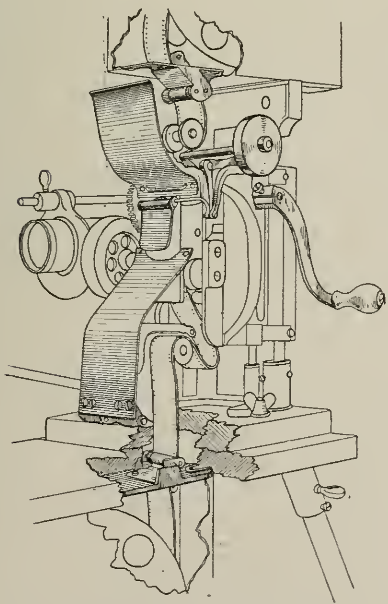


Fig. 74. Cameragraph Safety Shutters, Style B

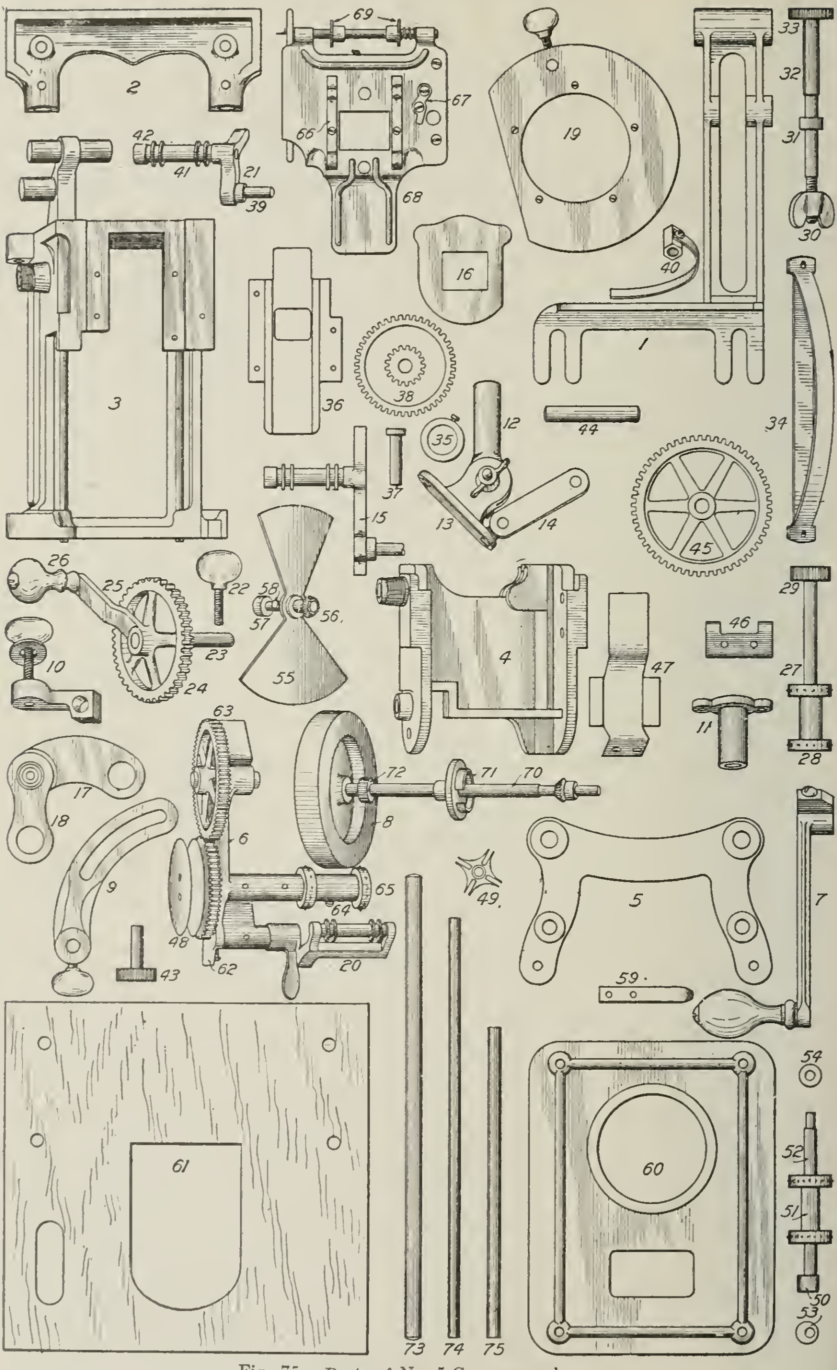


Fig. 75. Parts of No. 5 Cameragraph

INDEX OF PARTS

1 Reel hanger frame
2 Machine top frame
3 Machine body frame
4 Machine framing carriage
5 Machine base casting
6 Take-up feed frame
7 Machine crank
8 Fly wheel
9 Stereo bracket with thumb screw
10 Stereo bracket holder
11 Crank shaft bearing
12 Framing device lever socket
13 Framing device clamp
14 Framing device link for lever
15 Top feed swing bracket
16 Cooling plate
17 Toggle joint, large arm
18 Toggle joint, small arm
19 Stereo flange collar casting
20 Take-up feed roller bracket
21 Intermittent roller bracket
22 Steel thumb screw, nickeled plain
23 Reel hanger shaft
24 Reel hanger gear
25 Reel hanger crank
26 Reel hanger crank handle
27 Heavy feed sprocket
28 Feed sprocket shaft
29 Feed sprocket gear
30 Wing nut
31 Set collar
32 Reel hanger spindle
33 Reel hanger spindle gear
34 Shutter shield
35 Toggle joint set collar
36 Aperture plate
37 Toggle joint spindle
38 Toggle joint gears
39 Intermittent bracket spindle
40 Intermittent bracket spring
41 Intermittent bracket roller
42 Intermittent roller set collar
43 Upper feed gear and spindle
44 Framing lever
45 Crank shaft gear
46 Steel peeler
47 Apron
48 Take-up feed driving pulley
49 Geneva or star wheel
50 Eccentric bushing
51 Intermittent sprocket, light
52 Intermittent shaft or spindle
53 Eccentric bushing (end view)
54 Plain bushing
55 Shutter, revolving
56 Shutter gear, each
57 Shutter set collar
58 Shutter spindle
59 Top feed bracket spring
60 Front plate
61 Base board for mechanism
62 Take-up feed roller bracket spring
63 Gears for take-up feed
64 Heavy sprocket for take-up feed
65 Take-up feed spindle
66 Film tension springs
67 Latch for door
68 Plate door or gate
69 Guide rollers, spindle bushings and springs
70 Pin wheel or Geneva driver
71 Main spindle
72 Steel pinion
73 Machine frame support
74 Machine frame support

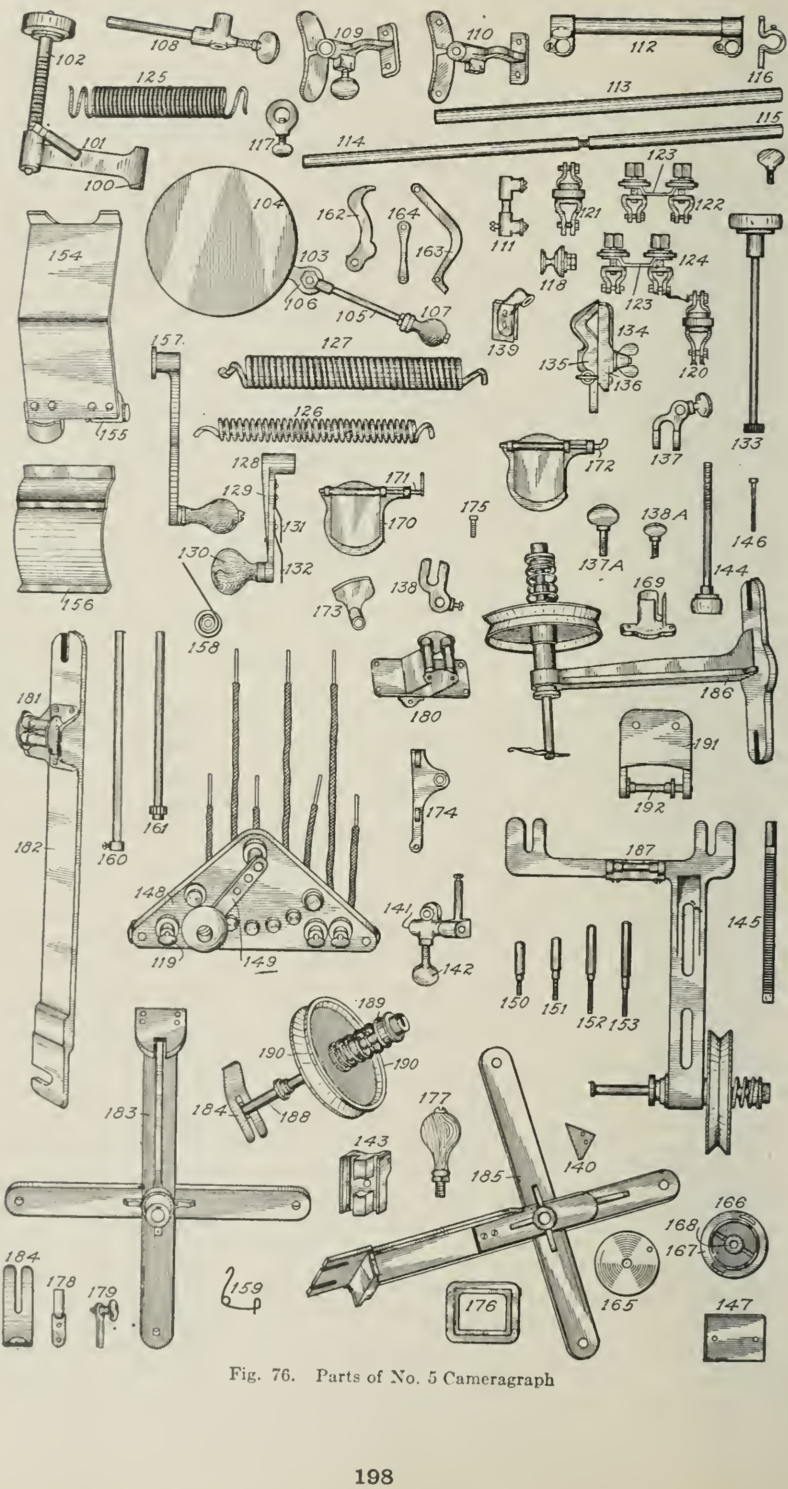


Fig. 76. Parts of No. 5 Cameragraph

75 Stereo lens bracket rod
100 Arc lamp base, complete
101 Arc lamp base casting, with post
102 Arc lamp base adjusting screws and handle
103 Dowser, complete
104 Dowser shield
105 Dowser handle
106 Dowser handle casting
107 Dowser handle knob
108 Funnel support
109 Condenser mount bracket casting, lower
110 Condenser mount bracket casting, upper
111 Rheostat binding post casting
112 Lamp house sliding, sleeve
113 Lamp house sliding rod, longitudinal
114 Lamp house sliding rod, crosswise
115 Lamp house sliding rod, extension
116 Lamp house sliding rod, holder bracket
117 Lamp house stop with thumb screw
118 Binding post for circular rheostat
119 Binding post for 25 amp. rheostat
120 Coil terminal for 25 amp. rheostat
121 Coil terminal for 25 amp. rheostat (end)
122 Coil terminal for circular rheostat (intermediate)
123 Jumper spring for circular rheostat terminal
124 Coil terminal for circular rheostat (double), complete
125 Coil for 120 volt circular rheostat
126 Coil for 25 amp. rheostat
127 Coil for 240 volt circular rheostat
128 Rheostat crank, complete
129 Rheostat crank casting
130 Rheostat crank handle
131 Rheostat crank contact spring, small
132 Rheostat crank contact spring, large
133 Arc lamp rack handle
134 Arc lamp carbon holder, complete
135 Arc lamp carbon holder jaw
136 Arc lamp carbon holder lip
137 Arc lamp carbon holder knuckle lower
137A Large plain thumb screw for knuckle
138 Arc lamp carbon holder knuckle upper
138A Small plain thumb screw for lower knuckle
139 Arc lamp carbon holder knuckle bracket
140 No longer used
141 Arc lamp supporting bracket
142 Arc lamp supporting bracket thumb screw
143 Arc lamp adjustment rack guide casting
144 Arc lamp adjustment rack handle, small
145 Arc lamp adjustment rack
146 Arc lamp adjustment rack casting pin
147 Arc lamp name plate
148 Rheostat (25 amp.) adjustment base, complete

149 Rheostat (25 amp.) crank, complete
150 Center post of 25 amp. adj. rheostat
151 Stop spindle on circular rheostat
152 Center post on circular rheostat
153 Upper magazine spindle
154 Lower film shield
155 Lower film shield hinge spring
156 Upper film shiel l
157 Machine crank for style "A" mechanism
158 Crank spring with button for style "A" mechanism
159 "V" spring for style "A" mechanism
160 Crank shaft for style "A" shutter mechanism
161 Crank shaft and pinion for style "B" shutter mechanism
162 Lever for style "A" shutter
163 Lever for style "B" shutter
164 Lever support for style "B" shutter
165 Friction case cover, style "B" shutter
166 Friction case cover, style "B" shutter
167 Friction shoe, style "B" shutter
168 Friction weights, style "B" shutter, each
169 Crank shaft bearing for style "A" shutter
170 Cooling plate and flap complete for automatic shutters
171 Rock shaft for style "B" shutter
172 Rock shaft for style "A" shutter
173 Left bearing for shaft, style "B" shutter
174 Right bearing for shaft, style "B" shutter
175 Pivot for lever, style "A" shutter
176 Ruby glass frame for lamp house door
177 Wooden knob for lamp house door
178 Catch holder for lamp house door
179 Catch for lamp house door
180 Valve for upper magazine
181 Valve for lower magazine
182 Support casting for lower magazine
183 Cross casting for lower magazine
184 Reel cotter
185 Cross casting for upper magazine
186 Lower take-up attachment
187 Front take-up attachment
188 Take-up spindle
189 Take-up spindle tension spring
190 Split pulley for take-up attachment
191 Guide roller casting for lower take-up attachment
192 Guide roller for lower take-up attachment

POWER'S NO. 6 CAMERAGRAPH

The intermittent movement of the No. 6 model is a radical departure from that of the No. 5 model, and indeed from all previous models of intermittents. It has no pin wheel, no star wheel, no Geneva. It is not a beater, dog, nor claw. Neither is it a friction grip. Two parts are used, similar in relation to the cam wheel and star of the Geneva, but rather reversing the order, since the pin wheel is the intermittent. The driving element is a revolving cam, substantially diamond shaped, upon the face of a heavy steel disk carrying also a steadying or locking band, as is carried by the pin wheel of a Geneva. The driven element is a cross upon the end of the intermittent shaft. In each of the arms of the cross is a pin. The cam band and diamond drive block upon the face of the driving disk are shown in Fig. 77, as are also the cross and pins, separated from their

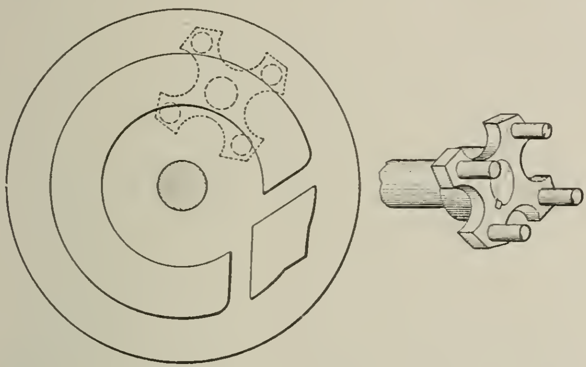


Fig. 77. Intermittent Movement Mechanism, Power's No. 6 Model

driving and locking elements. The position of the pin cross is shown in dotted lines in the locking band. In manufacture, the cross and pins are cut from a single block of steel. The parts of the intermittent movement are enclosed in an oil-tight casing, with an oil feed cup, and by keeping the casing properly filled with oil a practically noiseless movement of the intermittent drive is assured, Fig. 78.

The shutter is of the three-wing type, and is mounted upon a spindle which projects forward from the front plate of the motion head, so that the shutter intersects the rays of light in front of the projection lens. The shutter is adjustable longitudinally of the spindle, so that it can be set close to the front of the lens whether a long or short focus of lens is used. The hub of the shutter consists of an inner and outer sleeve; the inner sleeve is directly and permanently attached to the spindle, and the outer sleeve is adjustable upon the inner sleeve to permit quick and accurate setting of the shutter with relation to the intermittent movement. The mountings of the shutter spindle are such that when the shutter is detached for packing the mechanism, the spindle is swung down into close contact with the front of the motion head, where it will be protected from injury in shipment. Owing to the rapid movement of the film produced by the new intermittent mechanism (one-sixth movement and five-sixths rest for each picture interval), the shutter wings may be cut narrower than in most shutters of the three-wing type, thereby giving the screen all possible advantage of the lamp. If the operator does not try to burn his lamp too brightly he should be able to

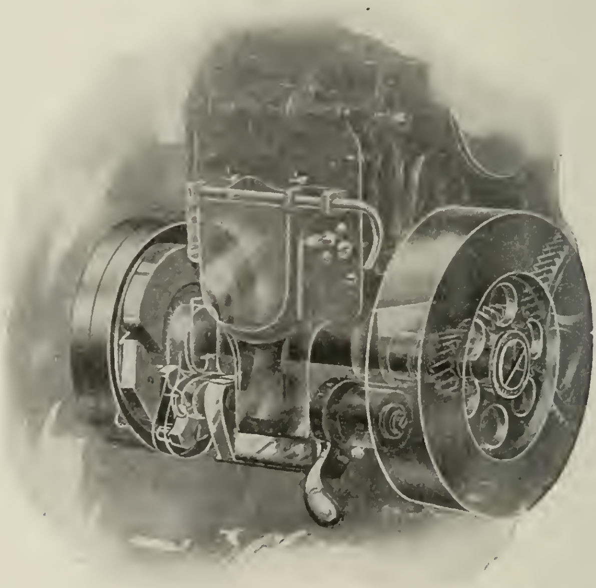


Fig. 78. Complete No. 6 Cameragraph Intermittent Mechanism

get his flicker well down toward elimination with the No. 6 model cameragraph, but if he tries to crowd on all the light he can from his lamp, the brighter illumination of the screen by the narrower shutter blade will bring back some of the flicker which the rapid film shift endeavors to reduce. The shutter gears are angle gears (not bevel gears), and have faces $\frac{3}{8}$ of an inch in width, thus insuring long service without perceptible wear.

SCENE FROM PHOTOPLAY, "HIS MISJUDGMENT"
Courtesy of *Thomas A. Edison, Inc., Orange, N. J.*

SYDNEY CARTON, JUST BEFORE HIS EXECUTION, STANDING ON SCAFFOLD
Scene from the Vitagraph Life Portrayal of "A Tale of Two Cities"
Courtesy of the *Vitagraph Company of America*

The picture is framed by a slight vertical movement of a carriage bearing the intermittent sprocket, and the framing lever is mounted on the base of the mechanism or machine head, where it

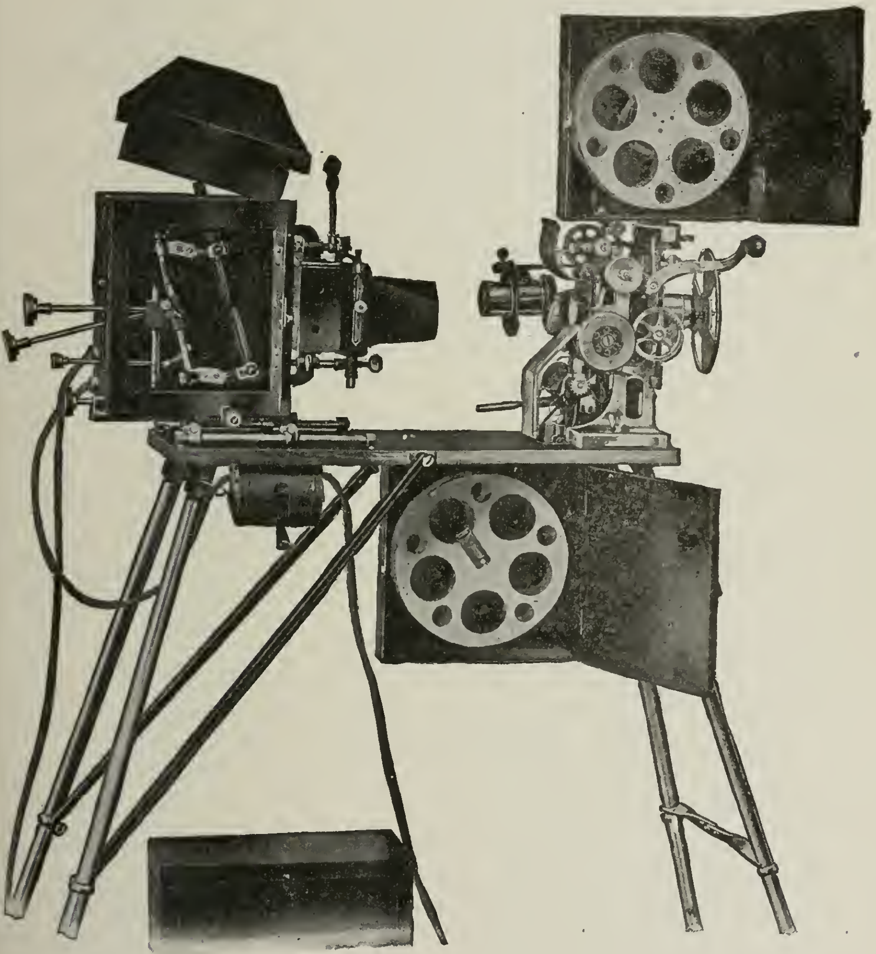


Fig. 79. Power's No.6 Cameragraph

can be readily reached with the left hand without interfering with the operation of the machine. The movement of the framing carriage does not alter the relation of the shutter to the picture gauge or projection aperture. The gearing connection to the framing carriage has all the gears arranged in a straight line, eliminating a toggle joint and toggle joint gears.

The film feed comprises three sprockets in accordance with the usual American practice. The top feed sprocket and the bottom or take-up feed sprocket run constantly, and the middle or intermittent sprocket makes a complete turn in four successive movements with alternate periods of rest, which are four times as long as the periods of movement. All the sprockets are cut from specially selected steel to insure long wear and accuracy of size and form.

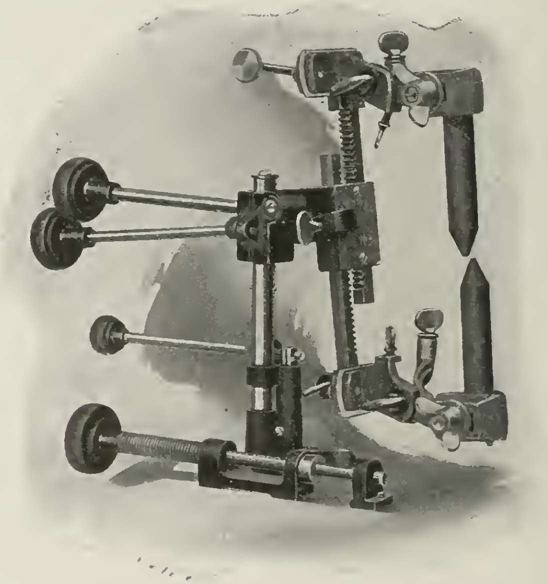


Fig. 80. Camerag aph No. 6 Lamp

The film is held in position upon the top feed sprocket by means of two rollers, one a flanged guide roller turning on a fixed spindle, and the other a holding roller mounted on a spring pressed bracket. The latter roller rests directly over the top feed sprocket when in use and keeps the film in perfect engagement with the sprocket teeth.

The film is held in position on the intermittent sprocket by means of a roller mounted on a pivoted bracket, which is so shaped that it serves also as a guide for the film. When the idler roller for the intermittent sprocket is in service it lies practically under the intermittent spindle and insures engagement of the film with at least four teeth on each hub of the intermittent sprocket.

A pair of idler rollers are provided to keep the film in position upon the lower or take-up feed sprocket, these idlers being mounted in a frame which is arranged to rock on a spindle carried by a spring pressed, pivoted bracket. The lower, or take-up, feed sprocket controls the rate at which the film is taken up in the lower magazine, and it is of the utmost importance that "riding" of the film on this sprocket be prevented. This is completely accomplished by means of the arrangement of idler rollers.

Fig. 81. Power's Rheostat

To prevent wear of the film in traveling over the sprockets, all the idler rollers which hold it in position thereon are so supported that no pressure of the film against the sprockets is produced by the idler rollers, but the possibility of disengagement of the film with the sprockets is completely obviated.

The film guides and friction devices are arranged to make the friction of the film through the motion head as light as possible. At the top of the gate a pair of light flanged rollers are provided through which the film travels to the aperture plate. The tension on the film necessary to insure steady pictures is produced between guide rails or wear strips of hard steel on the aperture plate and a pair of tension springs provided with half-round hardened steel tension contact shoes. To prevent wear on the film in passing from the intermittent sprocket a steel apron with polished surface is provided, over which the film travels with but little friction. The usual safety devices of upper and lower film magazines, fire shields, fire traps in the magazines, film shields, and safety shutter are used in the No. 6 model and are similar to those described in the No. 5 Model Cameragraph.

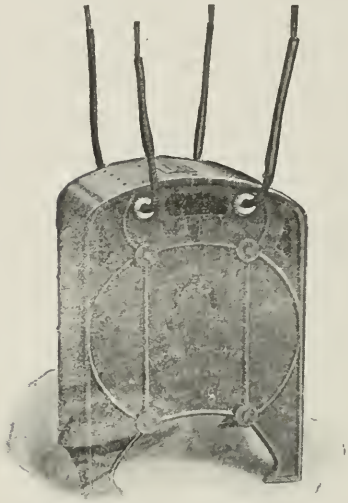


Fig. 82. Power's Inductor

The lamp house of the No. 6 model has its four adjustments outside of the house, the lamp being mounted upon an iron frame inside the house, and being accessible from all sides by reason of doors in both sides of the house and a swinging top upon the house as well.

The No. 6 cameragraph mechanism is shown in Fig. 79, and the No. 6 cameragraph lamp in Fig. 80. The Power's rheostat, which accompanies the Power's projecting machines, is shown in Fig. 81. The knob on the front may be moved to the right or to the left to change the amount of current taken by the arc lamp from the power mains. For alternating current only, the rheostat of Fig. 81 may be replaced by the Power's Inductor Fig. 82, but not for direct current.

PATHE PROFESSIONAL MODEL PROJECTOR

The Pathé projecting machine introduced into America is the type known as their "Professional Model." The Pathé machine differs in one essential respect from all other projecting machines which have reached any wide sale in America, in that it is made entirely in Europe, being made in the Pathé workshops in Paris. The shops there employ over five hundred people in the manufacture of projecting machines, and the output is four hundred complete machines per week, the result of gradual growth from a beginning which dates back to the beginning of the industry. This data is here given to inform the reader that the Pathé Professional Model projector, which is a new machine to the American public and to the American branch of the motion-picture industry, is not an experiment.

Not the motion head alone, but every part of the entire machine is made in Paris. It is urged as an advantage that Europeans are very accurate and careful in building machinery; that owing to the very low price of labor more time can be given to the work of each machine; and that as a consequence the Pathé Professional Model projector is carefully and perfectly constructed. Against this, it is urged that the foreign manufacture is an objection to the Pathé machine, upon the assumption that in the case of a breakdown it would be hard to obtain repairs. Waving aside as biased the usual manufacturer's claim that the machine is incapable of breakdown, full weight still must be given to the fact that Pathé Frères carry a complete stock at their American factory at Bound Brook, New Jersey, and at their offices and supply stations in New York, Chicago, and San Francisco.

All this is not for the purpose of boosting the Pathé machine, but for the purpose of making the reader familiar with some facts of interest in connection with the motion-picture industry, and to brush away that prejudice which the patriotic American attaches to everything of foreign manufacture. The Pathé machine is one of the foremost in use in America today. In the early days, there was no sale for a machine of so high a price, but with the steady growth of the industry Pathé Frères began to push their machine and it found a wide market.

The complete Pathé outfit is shown in Fig. 83, the view being taken from the operator's side of the table.

The intermittent movement is a one-pin Geneva mechanism. The star wheel and pin cam are placed in a lubricating box to reduce friction and wear and also to reduce noise. The construction of the intermittent mechanism is calculated to give a ratio of six to one, that is, one-sixth motion and five-sixths rest for the total picture interval. This is with a view to giving a sharp picture free from flicker. When the light is not crowded to its limit, the Pathé projeetor is eapable of very delightful projection, and the operator should set about getting it. With the stiff table legs and the floor "soeles" as Pathé Frères prefer to call them, the machine can be made rigid. In connection with this, the manufacturers recommend an arc light using only twenty-five amperes.

Fig. 83. Pathé Professional Outfit

The shutter is placed in front of the lens. It is a three-wing multiple-blade disk shutter, sixty degrees in each wing, the American standard shutter for all modern machines.

The film feed system is the American standard, triple sprocket system. The top sprocket runs continuously, feeding the film from the top magazine; the middle sprocket is intermittent, for stopping the film for exposure upon the picture screen; the lower sprocket runs steadily and feeds the film into the take-up reel in the lower magazine. The film does not touch the mechanism in any way in the center or picture strip of the film, but only in the edges where

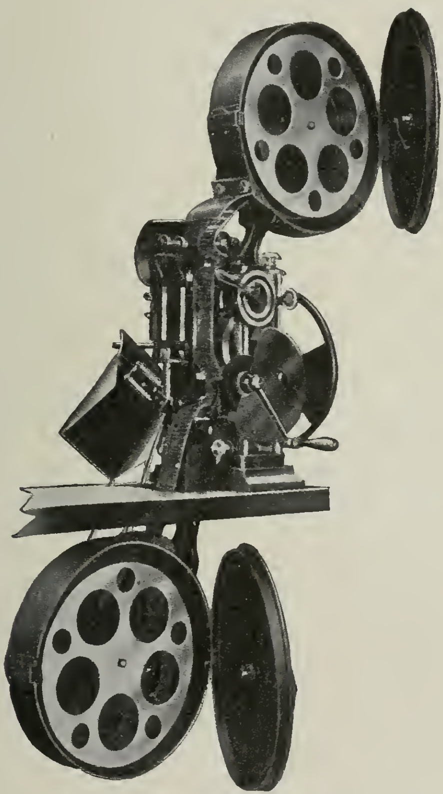


Fig. 84. Pathé Mechanism with Magazines (rear view) Open

the perforations are placed, reducing as much as possible the pull or friction upon the film and the probability of scratching or damaging it.

The framing device is worked by a small lever which raises or lowers the picture, and which can if desired be locked in position by a thumb screw.

The automatic fire shutter holds the film window of the motion head normally closed; it is operated to lift out of the beam of light only after the motion head has begun to turn, and as soon as the speed is reduced for the purpose of stopping, the shutter again drops into position in the beam of light and protects the film in the window.

The flame shields protect the film from exposure to the light and heat of the lamp and lamp house from the time it leaves the upper magazine until it is wound into the lower magazine.

Fig. 85. Pathé Arc Lamps

The flame shields are hinged at the left, as are also the safety shutter and the film gate, so that all of the parts in front of the film as the operator views it, looking at the back of the motion head, may be swung out of the way for inspection, for cleaning up the path of the film, and for threading up the film through the motion head. Fig.

84 shows the motion head thus opened, showing also the magazines open and the position which the film assumes in its passage through the motion head.

The fireproof magazines (upper and lower) are round, with hinged doors, and roller film outlet and inlet. The film passes through between two rollers which are fitted together tightly enough to prevent flame from getting through into the magazine, yet are so constructed as not to scratch or injure the film as it passes between them.

The reels in the magazines are of steel, and are of the standard 10-inch size for 1,000 feet of film.

The lamp house is of large size. It has doors on both sides and a slide in the rear, in addition to which the top lifts off, enabling the operator to get at the lamp from all sides, and from the top. The lamp house is attached to the table by a system of adjustable sliding rods which permit a forward and backward movement, as well as a side movement to the position for the stereo lens when slides are to be projected.

Fig. 86. Pathé Anti-Shake Socle

The condenser glasses are placed in a cell which is so designed as to be taken out of its support easily when the lamp house is hot. The condenser glasses are of the standard American size, 4½ inches in diameter, and any condensers of this size used in any other projecting machines may be used in the Pathé Professional—it is not necessary to use an imported glass.

The slide carrier is of metal.

The arc lamp is made of heavy steel and bronze; the lamp itself, removed from the case, is illustrated in Fig. 85. By means of the top fiber knob, the operator is enabled to feed the carbons; by means of the next knob, the small one, the operator is enabled to shift his light from left to right or from right to left; by means of the large knob third from the top, the operator is enabled to raise or lower the light; and by means of the bottom knob he is enabled to move it forward or backward and still keep it under perfect control all of the time. The carbon holders are held in place by an automatic device which does away with the necessity of tightening them with a screw. This automatic device also prevents the carbons from falling because of the expansion of the metal parts holding the carbon when the lamp heats up. The angle or slope of the carbons is not adjustable.

The table is a wood top with adjustable legs. Each leg is two telescopic steel tubes, held together by a thumb screw. This is shown clearly in Fig. 83. By the adjustable legs, the table may be leveled, or may be tilted at any desired angle to get the best picture upon the screen possible from any enforced location of the projector. The legs may be attached rigidly to the floor, and the table shake may be eliminated by the use of a set of Pathé "socles," illustrated in Fig. 86.

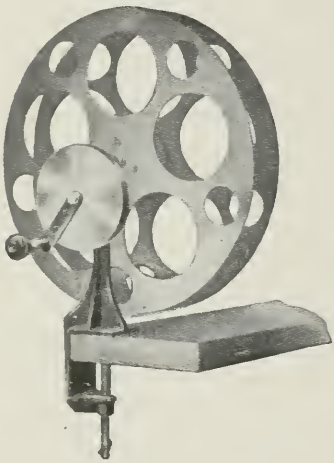


Fig. 87. Pathé Film Rewinder

Rewinding of the film reel is not done with the motion head but with a separate simple rewinder, illustrated in Fig. 87.

In Fig. 88, the repair parts most likely to be needed are illustrated and numbered, and a list of parts by name and number also is given.

To thread up the Pathé Professional, first open up both gates and both magazine doors, opening up the back of the motion head as is shown in Fig. 84. See that the framing lever, the small brass handle on the right side of the machine, is about in the center of its motion, that is, the lever should be approximately over the "h" of the word "Pathé" on the quadrant in which the framing lever turns.

Place the film reel in the upper magazine so that the film unwinds from the top. Next, pass the end of the film between the two magazine rollers in the film outlet which is found on the lower part of the magazine. Close the upper magazine door. Draw out about a foot of film and mesh it over the upper socket. Now place the film in the film track, first, however, making a loop interiorly in the film between the upper sprocket and the film track. Mesh the film over the intermittent sprocket, holding the loop in place with the right hand, and close the upper gate. Turn the shutter with the hand until the film moves down, then mesh the film over the lower sprocket, allowing for a loop as described above. The lower loop should be made just long enough to avoid touching the lower chain gear shaft. A turn of the operating handle now will draw film enough through the machine to enable the operator to pass it between the rollers at the film inlet of the lower magazine and from there to the reel hub, where it is fastened in the usual manner. Turn the reel by hand to tighten up any slack film and close the lower magazine door and the lower film gate and flame shield. Be sure that the groove in the lower reel fits snugly to the pin in the lower magazine spindle. Both the top and lower reels are designed to turn *counterclockwise* and on no account should the spring belt of the magazine be crossed to reverse the motion of the lower reel. The tightness of winding of the lower reel can be regulated by tightening or loosening the two milled nuts on the lower magazine spindle.

The manufacturers offer the following special suggestions for the care of the Pathé Professional:

The fact that a machine is strongly built is no reason why it should be abused. All machinery requires lubrication, and a motion-picture machine is no exception to the rule.

There are two oil cups on the shutter shaft. Two on the upper sprocket shaft and two on the lower. Three on the fly-wheel shaft and two on the intermittent sprocket shaft. One on the upper chain gear and one on the toothed gear on the right-hand side of the machine. There is also another spur-gear shaft on the right-hand side with two oil cups.

The star wheel runs in oil and the lubrication case should be filled daily. The star wheel is the most important part of a motion-picture machine, as upon it the steadiness of the picture depends. The star wheel in the Pathé Professional machine is accurately adjusted at the factory and should not be meddled with.

Only the best quality of machine oil should be used for lubricating the working parts.

The film tracks and sprockets should be kept clean by being brushed occasionally with a clean tooth brush. The film tracks may be rubbed occasionally with a very small quantity of vaseline.

The window frame is removable for cleaning purposes. It should not be cleaned with a knife or other sharp instrument, but should be rubbed with a clean stick of wood. A very small quantity of gasoline sometimes is useful in cleaning the film sprockets and tracks.

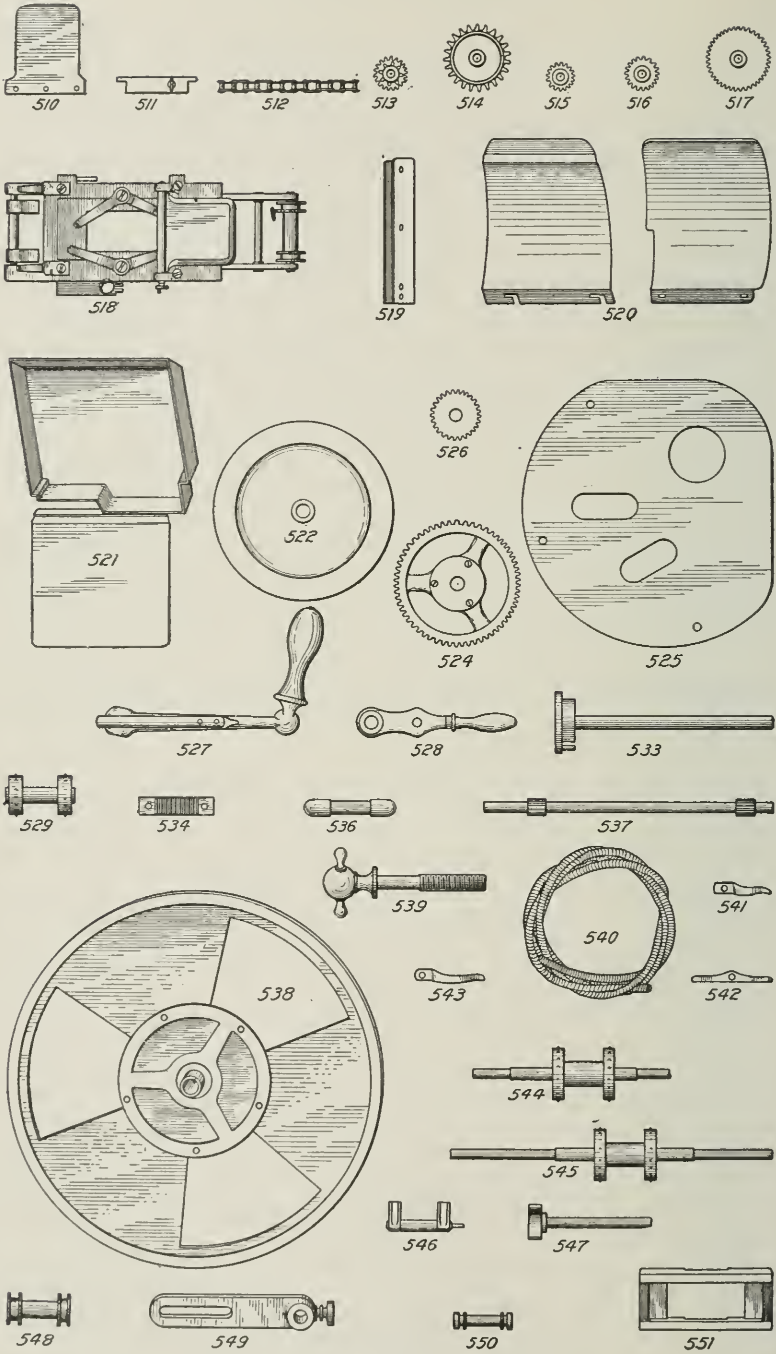


Fig. 88. Pathé Professional Model Parts

INDEX OF PARTS

501 Arc lamp
502 Asbestos-covered wire with terminal
503 Oak board
504 Lamp house, sliding base and cone
505 Legs and flanges, complete set
506 Mechanism head without reels, magazines or lenses
507 Rheostat
508 Slide carrier
509 Double pole switch and cover
510 Automatic shutter shield
511 Bolt
512 Chain
513 Upper chain cogwheel and gear
514 Lower chain cogwheel
515 Steel cog gear, 28 teeth
516 Steel cog gear, 35 teeth
517 Steel cog gear for take-up
518 Complete door with shutter
519 Steel film track
520 Upper flame shield
521 Lower flame shield
522 Fly wheel
523 Framing cog gear
524 Bronze gear, 112 teeth
525 Gear guard
526 Gear for shutter shaft
527 Handle
528 Handle for framing device
529 Intermittent steel sprocket
530 Upper magazine
531 Lower magazine
532 Milled screw
533 Steel pin wheel
534 Rack
535 Steel reel, 10-inch
536 Roller for magazines
537 Shaft and gear for framing
538 Shutter
539 Socket screw
540 Spring belt
541 Spring for tension holder
542 Spring for top of door
543 Spring for window frame
544 Upper sprocket with shaft
545 Lower sprocket with shaft
546 Steel sprocket tension holder
547 Steel star wheel
548 Upper steel roller
549 Stereopticon attachment
550 Steel tension roller for take-up
551 Steel window frame
552 Binding post
553 Carbon holder
554 Shaft with fiber knob and gear
555 Cone
556 Hood
557 Fiber knob for door
558 Red glass for door
559 Sliding base
560 Sliding rod, 15 inches
561 Sliding rod, with screw end, 16 inches
562 Condenser lens, bi-convex, $4\frac{1}{2}$ inch diameter
563 Condenser lens, plano-convex, $4\frac{1}{2}$ inch diameter
564 Condenser lens, meniscus, $4\frac{1}{2}$ inch diameter
565 Condenser mount without lens
566 Motion picture jacket
567 Motion picture lens, any focal length
568 Stereopticon lens without mount any focal length
569 Stereopticon mount without lens

THE STANDARD PROJECTOR

The unique feature of the "Standard," or "American," projector is in the film protection. Other machines provide fireproof magazines and numerous devices for protecting the film from the heat of the lamp, while passing from the upper to the lower magazine, and still other shields for preventing the film from coming in contact with the lamp house when running out of the projecting head under the feed of the upper sprocket.

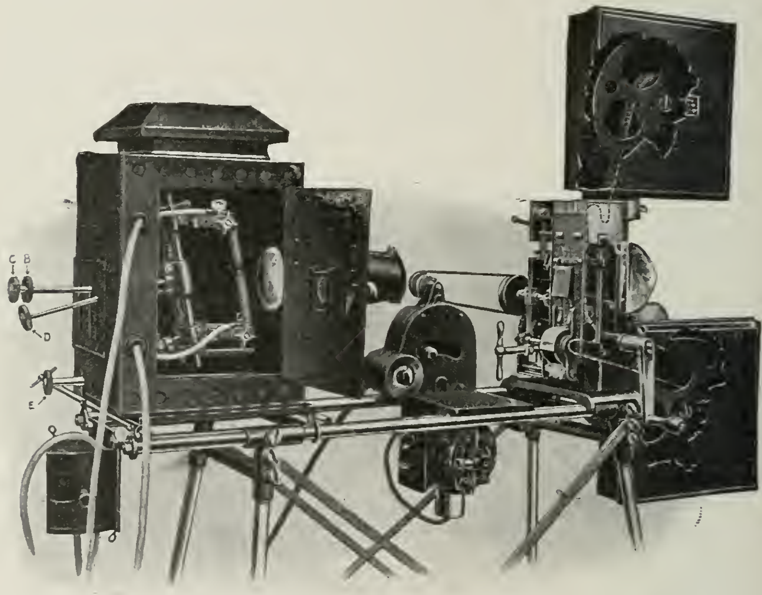


Fig. 89. No. 2 "Standard" Automatic Moving-Picture Machine with Motor

The "Standard" attacks this problem in a different way. A complete enclosed housing for the film is created, including the upper reel, the motion head, and the lower reel. The entire length of the film strip is protected and is completely enclosed, with the exception of the single image in the film window. The motion head is box-like in construction. The upper feed magazine is placed over the motion head and close upon it, leaving no space between in which the film can be exposed in passing from the feed magazine box to the motion-head box. The lower take-up magazine is placed just below the projection lens and against the front of the motion-head box, leaving again no space between where the film is exposed in passing from the motion head to the take-up magazine.

Because of the close fitting of the magazines to the box body of the projection head, no film-friction film outlets are used upon the magazines, either upper or lower, a flame trap being built into the box-like motion-head frame.

The close construction of the three parts, upper magazine, motion head, and lower magazine, and the full protection of the strip of film, is shown clearly in Fig. 89, giving a general view of the "Standard" projection equipment. Not only are the motion head and magazines shown, but also the "Standard" table, built wholly of metal rods and tubes, the lamp house, and the motor. The showing of the motor in the picture recalls the fact that at one time the "Standard" was the only projection machine which was permitted to run by motor in New York, all others being compelled to turn by hand. The feature of distinction upon which this discrimination was based was that the film could not be fed by the motor and upper sprocket to make contact with the lamp house or to fall into the beam of light outside of the motion head, because of the enclosed box construction of the entire film-handling mechanism and magazines.

The "Standard" does not use the opaque shutter, but uses a semi-opaque or translucent shutter which gives a soft haze to the picture screen during the short interval of shift of the film. By changing the interval of darkness into an interval of haze, the flicker is reduced; and the claim is made also that an equal screen illumination is produced with a smaller current consumption in the lamp. This, however, lies with the operator; the rule of *less light and smoother picture* or *more light and more flicker* is a fundamental principle in the optics of the motion-picture system when projection by persistence of vision is practiced, and it applies to the "Standard" machine along with the others. There is room for the exercise of the operator's skill with all of them in the matter of flicker.

The operator must discriminate between "flicker," which is the variation of the intensity of the light by which the screen seems to wink at the spectator, and "jiggle," which is the dancing about of the fixed objects of the projected picture, due either to faulty intermittent mechanism or film gate adjustment, or to an unsteady table which yields to the force applied to the crank handle.

The single image of the film which is in the film window is

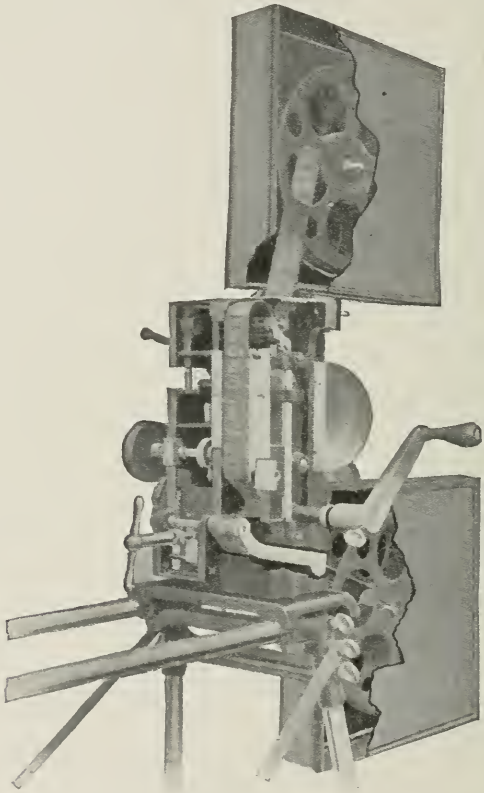


Fig. 90. "Standard" Motion Head

guarded from the heat of the lamp by a hinged shutter which falls over the window when the driving mechanism of the machine is not in motion. When the motion head is being driven at projecting speed, a speed governor acts to engage and lift the safety shutter from the film window, and to hold it up as long as the speed of the motion head continues, dropping it before the window as soon as the motion stops.

BETTY STIRS THINGS UP A BIT
Scene from Pathé film, "Betty's Pranks"
Courtesy of *Pathé Frères, New York and Paris*

SCENE FROM "THE DAYS OF NERO," BY GAUMONT
Probably the Greatest Portrayal of This Time in History, That Has Ever Been Given the American Public
Courtesy of the *Kleine Optical Co., Chicago*

The intermittent movement of the film is obtained by the usual arrangement of Geneva mechanism. The Geneva pin wheel is so built that when the pin becomes worn a new one may be installed to replace the worn one.

The lamp house is adjustable toward or from the motion head by sliding its cross track directly upon the two metal tubular rails which form the top bars of the operating table or frame. The cross track is a pair of parallel bars to permit the lamp house to be slid over for the stereo lens of the motion head as required.

The construction of the motion head and the course of the film through it is shown in greater detail in Fig. 90, where the side of the motion-head box and the film gate door and back plate or "back door" of the motion head are removed to reveal the mechanism.

The principal parts of the "Standard" machine which are likely to be required for repairs are shown in Fig. 91 with their identification numbers; in addition, a list of the parts by name is given with their numbers.

The lamp of the "Standard" machine removed from the lamp house in order to reveal all of its parts, is shown in Fig. 92. The knob *D* feeds the carbons. The knob *B* for tilting the lamp and the knob *C* for raising and lowering it are together, the knob *C* being upon a rod and the knob *B* being upon a tube which is sleeved over the rod. This distinction of a double knob as compared with a single knob will help the operator to avoid the error of turning the wrong knob and throwing his screen lighting out of adjustment when, with his eyes on the screen and his right hand turning the crank, he reaches with his left hand to feed the carbons. If, under such circumstances his hand touches the double knob, he will not turn it by mistake. The knob *E* moves the lamp toward or from the condensers.

The adjustment of the angle of the carbons with respect to each other is attained only through the door of the lamp house, by turning the knob *G* for the lower carbon, or *H* for the upper carbon. By these knobs, the carbon holders may be set for direct-current or alternating-current positions, the difference in alignment between the centers of the upper and the lower carbons of the direct-current setting also being controlled by the knobs *G* and *H*. Knobs *A* and *F* are lock knobs for the carbon pencils in the holders.

INDEX OF PARTS

1 Star wheel and spindle (one piece)

2 Bushing on intermittent spindle (short)

7 Collar } On fly wheel spindle
8 Gear } On fly wheel spindle
9 Bronze bearing } On fly wheel spindle
10 Collar } On fly wheel spindle

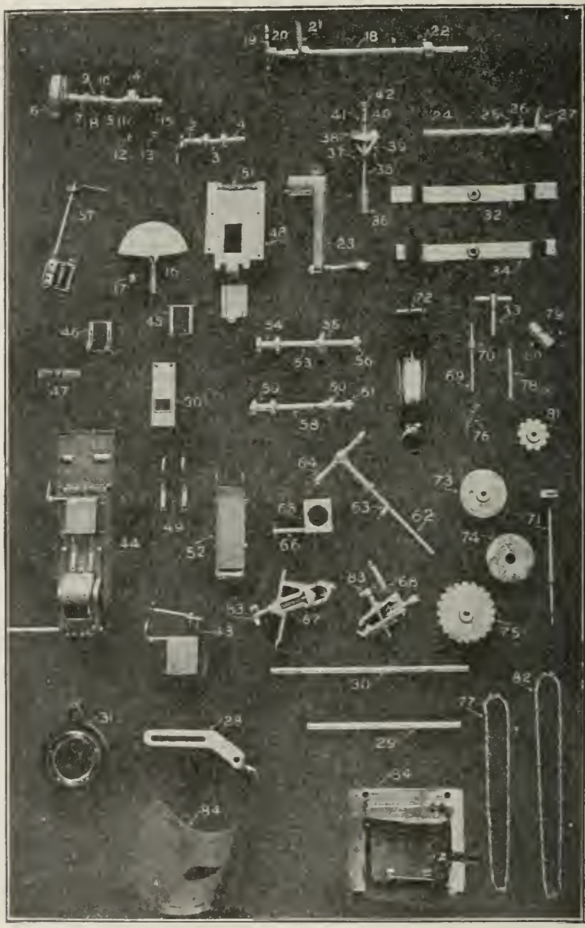


Fig. 91. Repair Parts for "Standard" Projector

3 Intermittent sprocket

4 Bushing on intermittent spindle

5 Fly wheel spindle

6 Fly wheel

11 Pin wheel

12 Engaging pin for pin wheel

13 Screw to hold pin in pin wheel (hardened)

14 Bronze bearing for fly wheel spindle
15 Gear connecting with shutter gear
16 Revolving shutter and spindle
17 Revolving shutter gear
18 Driving shaft spindle

19	Chain sprocket	On driving shaft
20	Collar	
21	Spiral gear	
22	Clutch collar	

23 Handle for driving (complete)
24 Transmission spindle

25	Gear 42 teeth	On transmission spindle
26	" 12 "	
27	" 15 "	

28 Stereopticon bracket
29 Stereopticon bar, short
30 Stereoption bar, long
31 Stereopticon ring casting
32 Mechanism fastening casting
33 Screw for mechanism fastening casting
34 Motor fastening casting
35 Governor spindle
36 Sliding gear on governor
37 Governor head
38 Governor wings (each)
39 Governor arms (each)
40 Governor pin
41 Governor collar
42 Gear on governor spindle (8 teeth)
43 Fire shutter (complete)
44 Door for machine (complete)
45 Aperture tension cradle
46 Film tension guide (intermittent sprocket)
47 Door lock (complete)
48 Film slide and cradle (complete)
49 Springs for aperture tension cradle (each)
50 Aperture plate
51 Guiding spool for film track (complete)
52 Film shute
53 Upper film sprocket spindle
54 Upper film sprocket

55	Gear	On upper film sprocket spindle
56	Collar	

57 Upper idler roller lever (complete)
58 Lower film sprocket spindle
59 Lower film sprocket

60	Gear	On lower film sprocket spindle
61	Collar	

62 Framing device spindle
63 Framing device eccentric
64 Framing device handle
65 Framing device sliding box
66 Screw adjustment for sliding box
67 Carbon holder for A. C. (each)
68 Carbon holder for D. C. (each)
69 Reel spindle (upper magazine)
70 Collar on reel spindle (upper magazine)
71 Reel spindle with collar and lock nut (lower)
72 Take-up bracket with tightening nut
73 Friction plate on lower reel spindle
74 Friction washer
75 Large chain sprocket on take-up
76 Spring on take-up
77 Chain on take-up
78 Spindle for eccentric on take-up
79 Eccentric bushing on take-up
80 Set screw for eccentric on take-up
81 Small chain sprocket on take-up
82 Chain (take-up to mechanism)
83 Carbon holder tightening screw
84 Switch and switch box with nickel base

To thread the film through the motion head, slide the full feed reel over the spindle in the upper magazine. Open the back door of the motion-head box. Pass the end of the film between the two flame-trap rollers on the top plate of the motion-head box near the upper sprocket; then under the upper sprocket; let the pair of clamp

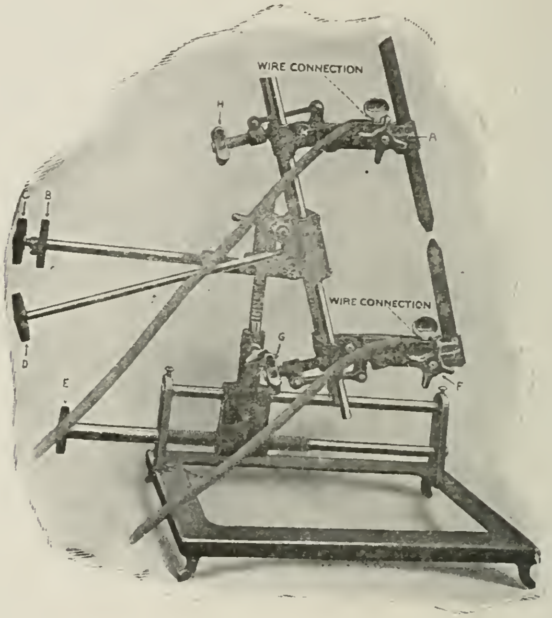


Fig. 92. Electric-Arc Lamp for "Standard" Projector

rollers rest upon the film, holding it against the upper sprocket. Turn the framing lever "up" as far as it will go, to make the upper feed loop as large as possible; then turn the fly wheel by hand until the intermittent sprocket just starts, then make an upper feed loop so that it will come ½ inch under the top plate of the motion-head box; pass the film down the guides and over the teeth of the intermittent; make a small loop to lower sprocket and close the door. The film passes through the lower chute to take-up magazine and is attached to the hub there in the usual manner. Take up the slack by turning the take-up reel by hand, and give a half turn of the driving crank to see that the film is being taken up properly before closing the door of the lower magazine. The precaution in forming the upper loop is necessary for the reasons that (*1*) if the upper loop is formed with the frame lever "down" by which the size of the upper loop may be increased when the frame lever is thrown "up," then the upper loop when thus increased may let the film rub against the inside of the top of the motion-head box; and (*2*) if the upper loop is formed as large as possible when the intermittent has just finished its pull, the upper steady feed will feed a full picture, or $\frac{3}{4}$ inch of film, into the upper loop before the intermittent pulls again, thereby increasing the size of the upper feed loop and perhaps permitting the film to rub against the inside surface of the motion-head box.

The take-up device is adjusted by a lock nut attached to the spindle of the lower magazine box. To adjust the tension, loosen the small screw in the lock nut. A turn then to the right will give more tension, and a turn to the left will give less tension. When the tension is readjusted to suit, tighten the small set screw in the lock nut again to hold the adjustment.

When the star wheel becomes worn or loosened, it can be adjusted to the pin wheel by loosening the four screws which hold the bronze bearings in place. To tighten the star wheel to the pin wheel, give both bronze bearings a slight but equal turn upward and again fasten the four set screws which hold the bearings fixed as adjusted.

The mechanism should be oiled thoroughly before beginning each afternoon or evening run. Do not forget to oil the leather washer between the flange and the large chain sprocket. Oil the spindle from an oil hole inside the box.

THE REWINDING "STANDARD" PROJECTOR

This projector is shown in Fig. 93. The take-up reel is in the square box below and in front of the motion-head box, while the feed reel, instead of being mounted edgewise above the motion-head box, is mounted flat.

The operation of this machine, which is classed as an "automatic rewinding projector," is not that it automatically rewinds the film, nor that it rewinds it at all, but that it uses the film for a second and third projection, and as many projections as required, without rewinding it at all. The top magazine, or feed magazine feeds from the middle of the reel.

Film reels received from the film exchanges usually are wound with the title end outside. When so received, the reel must be rewound before it is placed in the feed magazine of this "Automatic Rewinder" machine; and indeed, when the film is received with its leader inside the roll, as this machine requires it, the film must be rewound twice, to get it into a roll with a large opening in the middle. Having reeled the film up with a large center opening, and with the leader and title inside of the roll, the roll is dropped into the horizontal round feed magazine, the leader end is taken in the middle

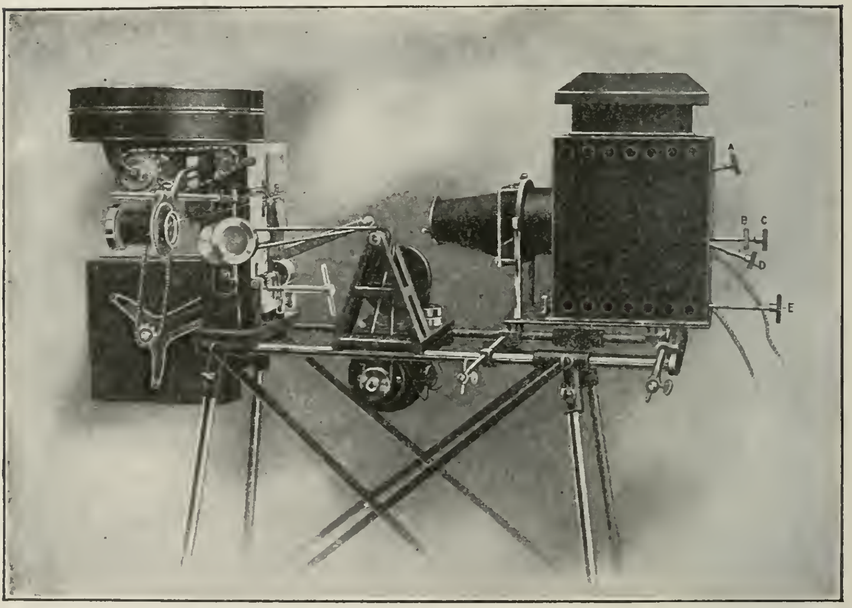


Fig. 93. The Rewinding "Standard" Projector

of the roll and is passed down through the floor of the feed magazine into the film inlet of the motion-head box, passing over the guides provided; the motion-head mechanism then is threaded with care for the upper and lower loop size, as described for the "Standard" machine, Fig. 90, and the leader end is taken into the take-up magazine and attached to the take-up reel, which has a large arbor, so that the film is rewound with a large opening in the middle.

Projection is made by crank or motor, the strip of film feeding from the center of the feed magazine and winding up, head in, upon the take-up device.

When the strip of film has been completed, the operator lets the tailpiece run through until it is completely wound upon the take-up reel. He then opens both the take-up magazine and the empty feed magazine, takes the film off of the take-up device without the reel, and places the film without the reel in the feed magazine, starts the inside end of the film down through the floor of the feed magazine and over the guides, threads up the motion-head mechanism, attaches the leader to the take-up mechanism, closes up the doors, and is ready for projection again, repeating as often as his program requires. When a program of two or three reels is being run, one reel after another, the old reel is lifted from the take-up device and placed flat in a metal storage box, placed upon the shelf flat to keep the open roll or hank of film from collapsing, and the new hank is dropped into the feed magazine. No rewinding ever is required except to get the film into proper form for the feed magazine when it is received from the film exchange or factory, and to wind it up again upon a small arbor to pack it in the small shipping box in which it was received from the exchange.

This machine is no longer offered for sale by the manufacturers, and theaters equipped with them may have the special magazines replaced with the later type, requiring rewinding, if the automatic rewinding feature is not entirely satisfactory.

THE SELIG POLYSCOPE

The old style Polyscope, made by the Selig Company, has been withdrawn from the market. It used the pin-shift mechanism controlled by two cams on the main driving shaft.

The Polyscope projector now sold by the Selig Company is illustrated complete in Fig. 94, and its motion head is shown in closer detail in Fig. 95, the door of the film gate being opened.

The film feeding mechanism is the American standard, three-sprocket, with Geneva intermittent drive.

In threading up the film, the feed reel is placed in the magazine on the top of the motion head, the end of the film is taken through the film outlet rollers, and the door of the feed magazine is closed.

By finger pressure upon a projecting lug, the presser roller is lifted from the upper constant feed sprocket until the film is placed upon the sprocket and meshed with the teeth.

The frame lever is now framed "down" to take out any slack which might be above the film gate, the film is placed in the track of the film gate with a slight slack above—at least one picture length—then meshed with the intermittent sprocket, and the film-gate

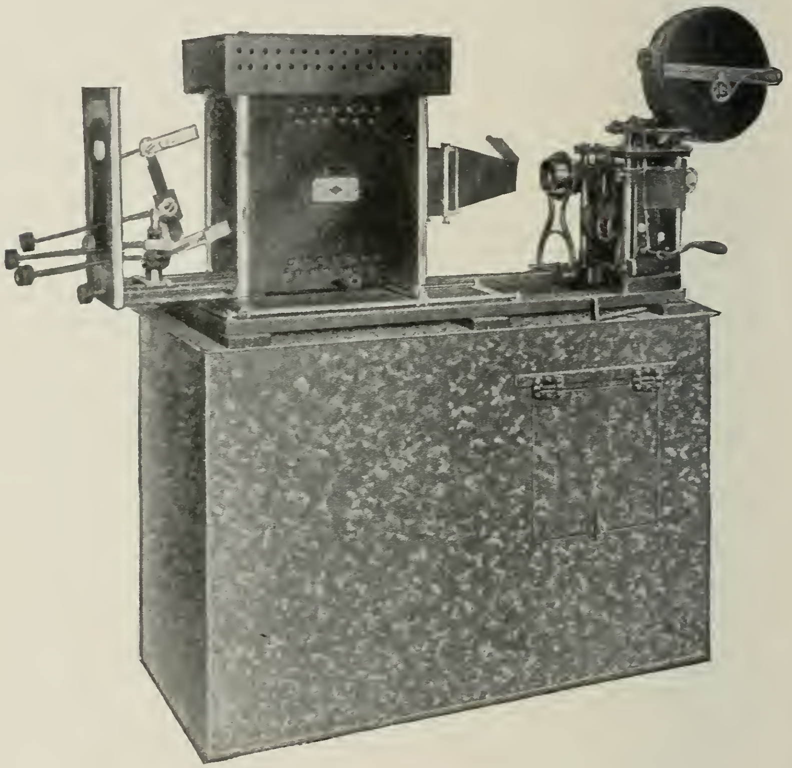


Fig. 94. Selig Polyscope Projector

door is closed. This causes the guide roller at the top of the door to engage the edges of the film, and presses the presser roller against the intermittent sprocket, both of these rollers being carried by the door. This step in threading might seem at first to require three hands on the operator, but the trick is to hold the end of the film below the intermittent with the left hand, to press the film above the motion-head frame with the long finger of the right hand and stretch it tight over the film window and along the film track of the gate, then

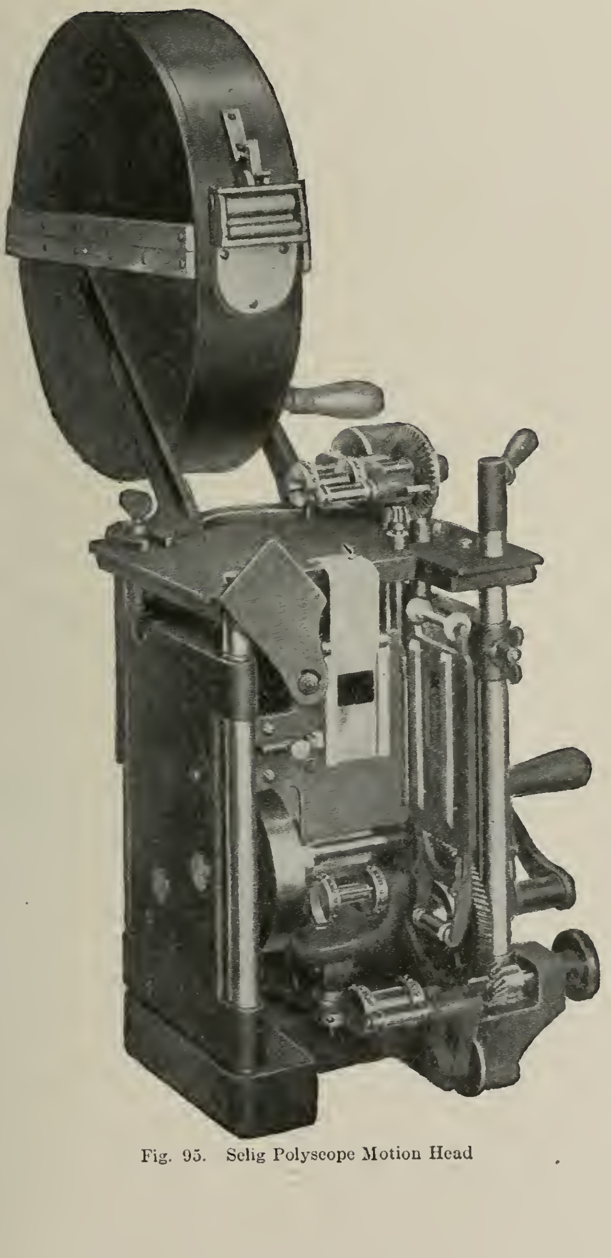


Fig. 95. Selig Polyscope Motion Head

to swing the door shut with the thumb of the right hand, which will be almost engaging the top guide roller of the gate.

Now frame "up" and give a little slack in the lower feed loop, then pass the film down into the magazine box, or to the take-up reel if one is used.

The Selig lamp house has the feature of sliding the lamp en-

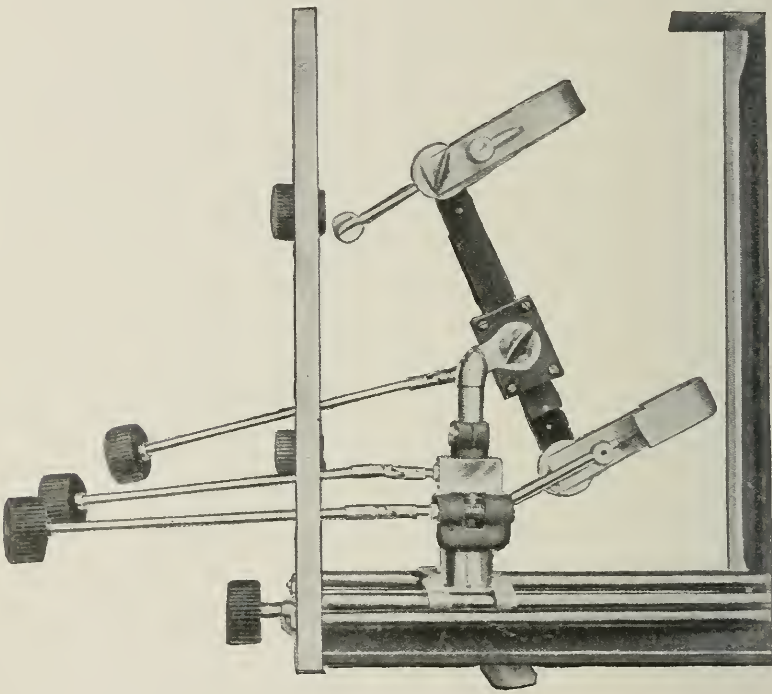


Fig. 96. The Selig Lamp

tirely out of the house to make inside adjustments, and to set the carbons. Fig. 94 shows the lamp withdrawn from the lamp house. Before projection is begun, the lamp is pushed in until the vertical panel at the back of the lamp closes with the body of the lamp house and forms a closed house. The controlling knobs have universal joints, permitting them to pass through very small holes in the back panel of the lamp house, and yet reach and operate their different parts of the lamp in any position of adjustment.

Four knobs are provided outside the lamp house, for lateral, transverse, vertical, and feed movements of the lamp. The angle of the carbons, either jointly for direct current or separately for alternating current, is adjusted by drawing the lamp from the house and working upon adjustments normally inside of the lamp house.

The Selig lamp is illustrated in detail in Fig. 96.

THE EDENGRAPH PROJECTOR

In the general design of this machine, the manufacturer has planned for the most direct film path possible, and for the separation of the film path from all entangling mechanisms as far as it is possible to do so. The path of the film is "in the open air" as completely as it is possible to make it, from the outlet of the feed magazine to the inlet of the take-up magazine. Fig. 97 shows the Edengraph in general view.

In Fig. 98 a close view of the motion head and magazines of the Edengraph are given, from which also the threading of the machine may be seen clearly.

After placing the feed reel in the upper magazine, the leading end of the film may be inserted into the outlet valve by slipping it through the slot in the side of the valve; it will then be properly placed between the two pairs of rollers, for there are four rollers in each of the film valves. The film is now carried around the upper sprocket, which is as close as can be to the upper film outlet, and is pressed to the upper sprocket by the single presser roller. The film is then taken over the flanged guide roller at the top of the film gate, the film gate is opened, and the film is carried down the film track to the intermittent, leaving a sufficient slack at the top of the gate for the top feed loop; the gate then is closed. The film is now brought around the lower sprocket and taken into the take-up magazine through another four-roller film valve and attached to the take-up reel in the usual manner. A turn of the crank will show that the take-up and feed elements are working properly, when all doors may be closed and the machine is ready for projection.

The film is rewound by a separate rewinder.

The gears of the motion head are all contained within the box-like frame, but are accessible by taking off the side of the box next to the stereo lens, first swinging the stereo lens out of the way, as shown in Fig. 99.

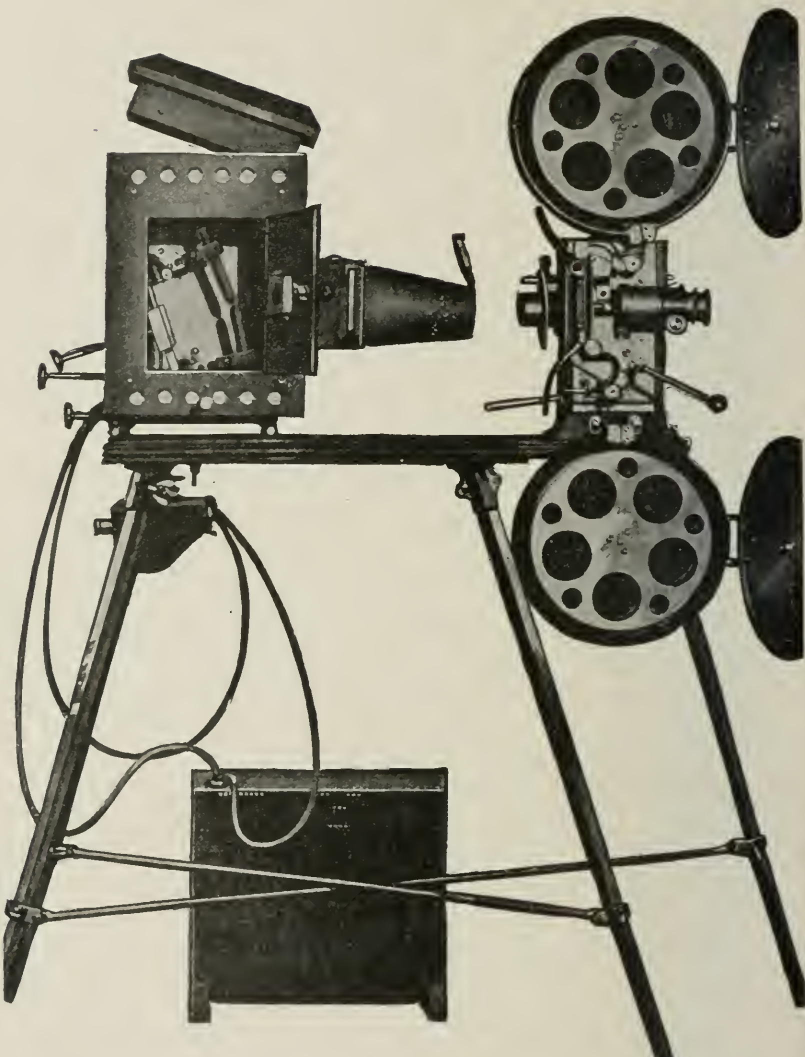


Fig. 97. The Edengraph Projector

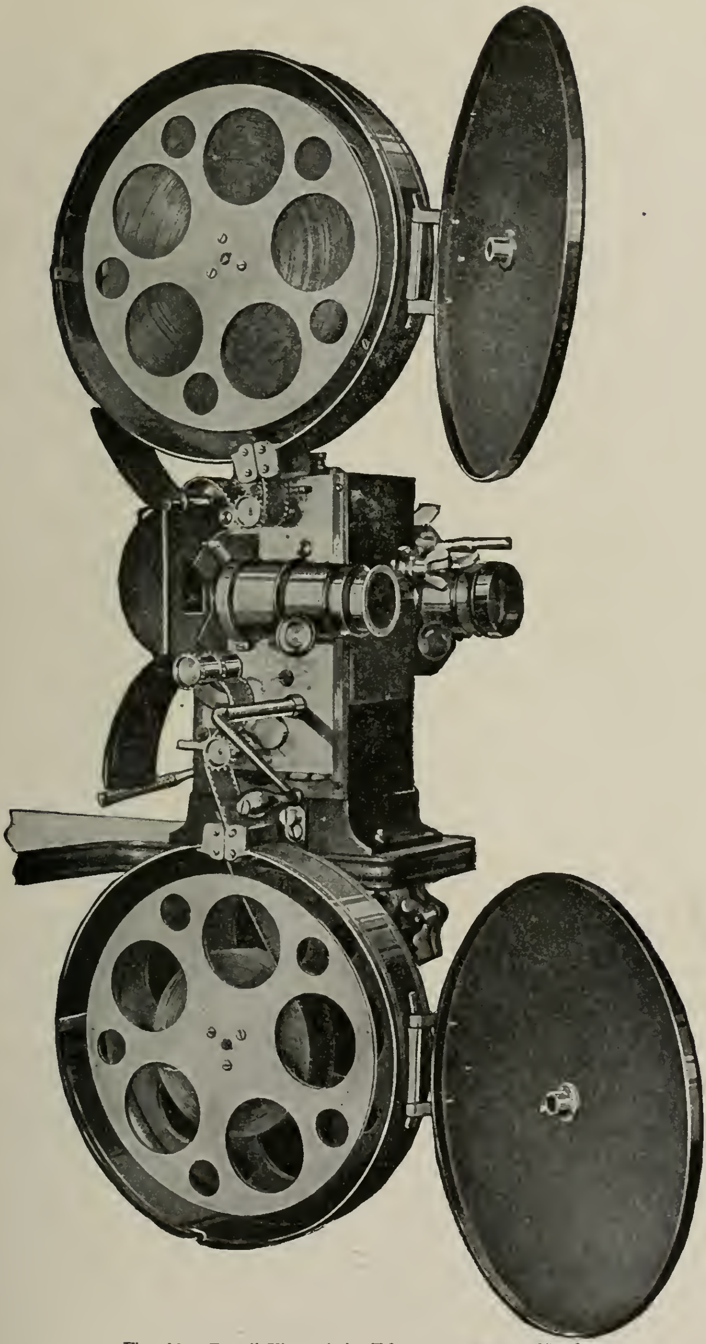


Fig. 98. Detail View of the Edengraph Motion Head

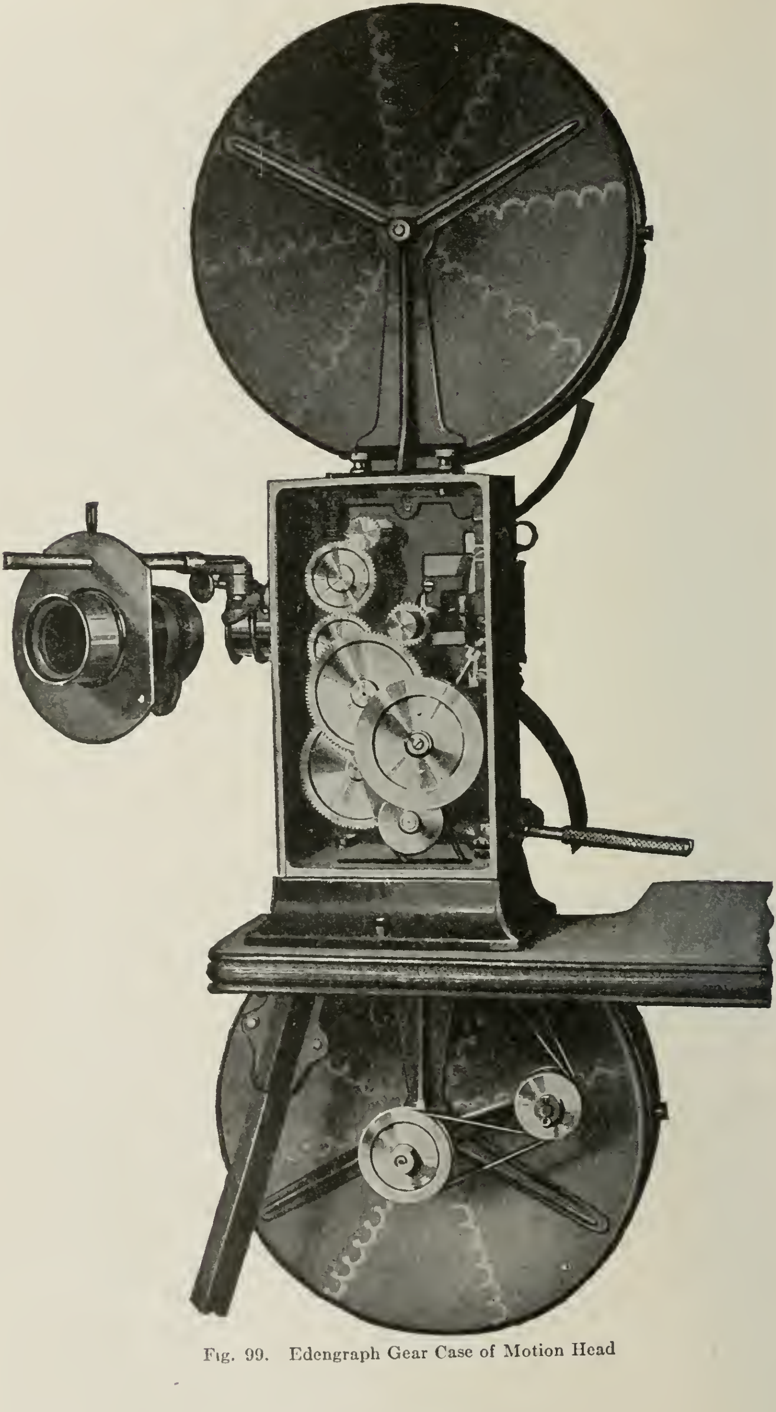


Fig. 99. Edengraph Gear Case of Motion Head

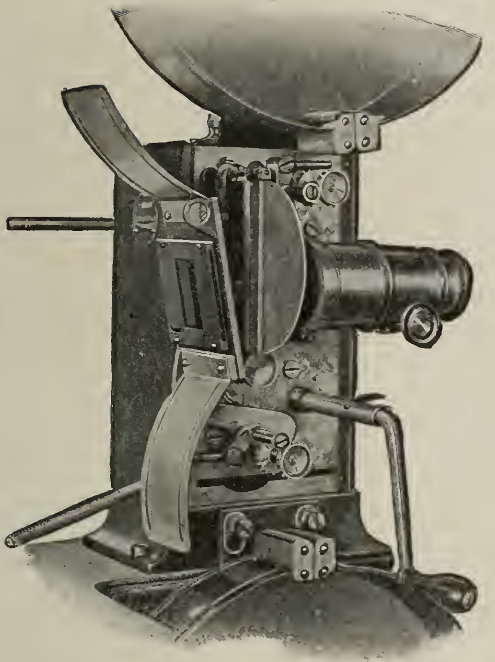


Fig. 100. The Edengraph Motion-Picture Mechanism with the Film Gate Swung Open on Its Hinge

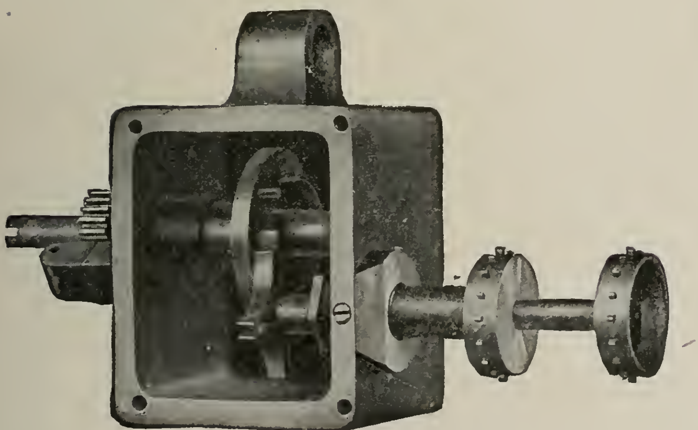


Fig. 101. The Edengraph Geneva Box

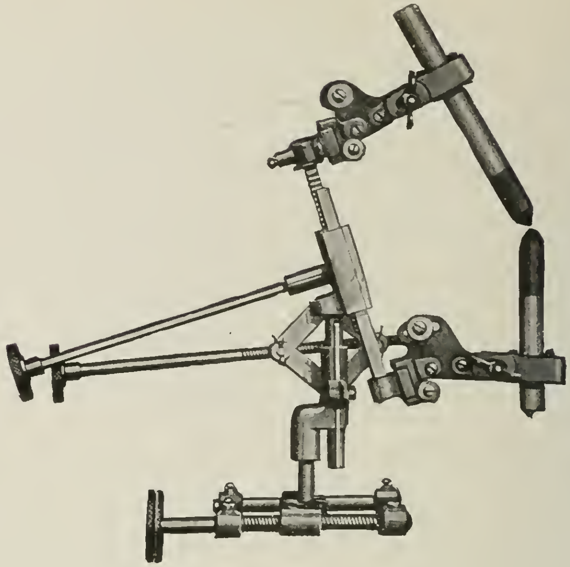


Fig. 102. The Edengraph Lamp Adjusted for Alternating Current

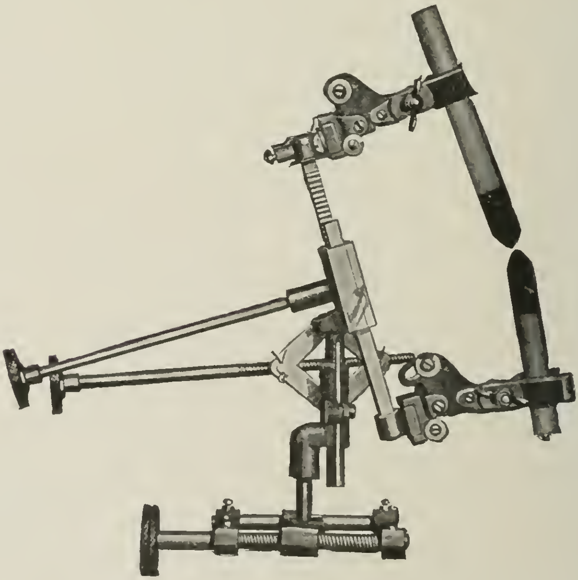


Fig. 103. The Edengraph Lamp Adjusted for Direct Current

SCENE FROM "LOST YEARS," BY GAUMONT

Illustrating the Remarkable Type of Motography Evidenced in the Modern Photoplay

THE SQUARE DANCE ON HORSEBACK
Scene from Photoplay, "An Unwilling Cowboy"
Courtesy of *G. Melies Company, New York*

The film gate door of the Edengraph is pivoted at the bottom, instead of at the side as is customary; the argument is that the pressure upon both edges of the film will be equal with this method of construction. The two fire shields are attached to the film gate door for the protection of the upper and lower feed loops. This detail is shown in Fig. 100.

The intermittent drive is the Geneva type of mechanism, enclosed in an oil box, the intermittent shaft projecting through the wall to pass outside of the motion-head frame to the film gate, Fig. 101.

The Edengraph lamp has three control knobs, the diagonal knob being carbon feed, the upper level rod being the adjustment for height, and the bottom knob being the adjustment for distance from the condensers. The adjustment for angle and the adjustment to the right or left is made inside the lamp house. Two views of the Edengraph lamp are given in Figs. 102 and 103, the lamp in Fig. 102 being shown adjusted for alternating-current arc and the one in Fig. 103 for direct-current arc.

THE LUBIN PROJECTOR

Lubin's "Marvel" is shown in general view in Fig. 104. A near view of the motion head, with the film gate door open, is shown in Fig. 105. In this device, the flame shield is pivoted to the operating table below, and attached to the gate door above.

The safety shutter is operated by a friction clutch, which must be kept clean and free from oil.

To set up the machine, the motion head is fastened to the table by means of the thumb screw which also holds the front leg of the table. The belt from the motion head to the lower magazine take-up shaft is crossed to turn the shaft in the proper direction.

The automatic fire shield must stand so that if the lamp house is in line with the mechanism the fire shield stands straight between the two. Hook the fire shield to the lamp house by means of the adjustable rod. When in proper position, the fire shield must almost touch the table.

Slide the electric lamp and the stand provided for it into the lamp house and fasten by means of the shortest handle, which also serves to raise or lower the lamp.

The condensers are placed in the holder with the round sides facing each other.

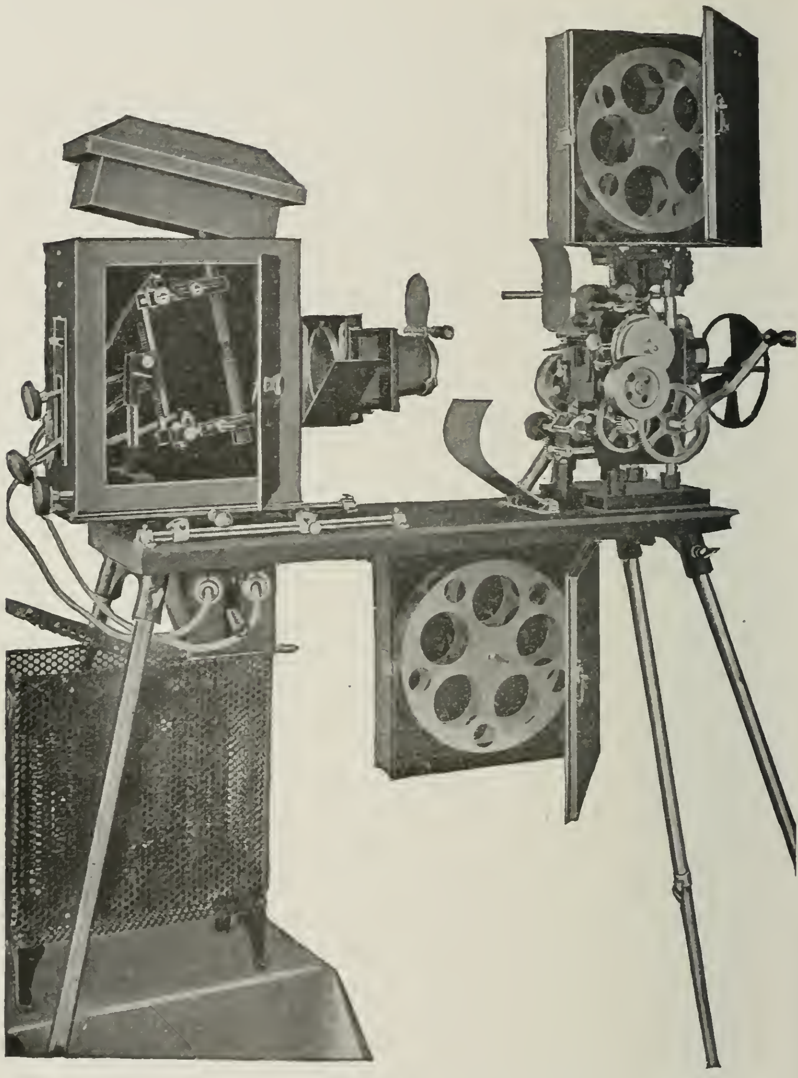


Fig. 104. General View of the Lubin Projector

To thread the film, push the lamp house to the left. This opens the fire shield and leaves the motion-head mechanism free. Place the full feed reel in the upper magazine. The film must unwind toward the left, and the emulsion or dull side of the film must be toward the lamp house, the figures, of course, being upside down, or heads down, and the leader or title being on the outside end of the

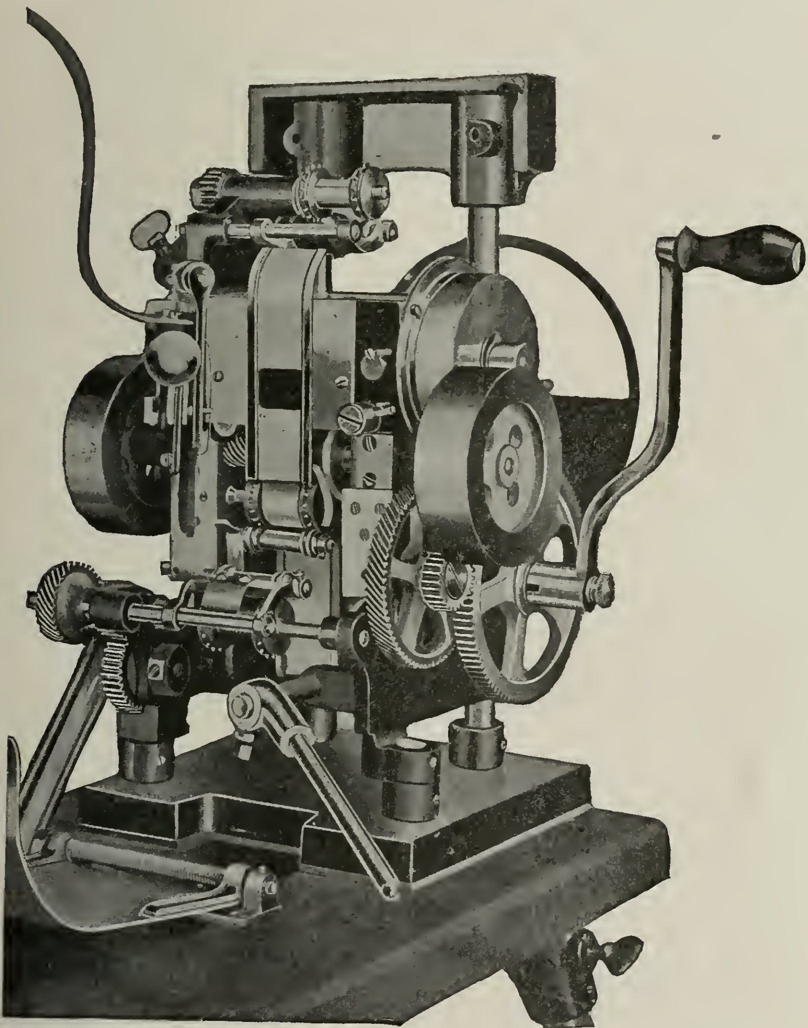


Fig. 105. Detailed View of the Lubin Motion Head

reel. Pull the film through the rollers of the flame-trap or film outlet attached to the lower part of the magazine. Close the door of the magazine and fasten with the catch. Bring the film to the top sprocket, press down the rollers underneath, lay the film around the right side of the sprocket and close the rollers to press the film against the sprocket, seeing that the teeth of the sprocket mesh properly with the holes in the film.

Open the film-gate door. Now press down the framing lever fully. This lowers the framing carriage. Bring the film between the door and the tension plate of the gate, carrying it accurately down through the film guide of the film gate, and close the door. This door may be closed before adjusting the film to the intermittent sprocket.

Pull up the film, so as to leave a loop big enough to place over your thumb between the top sprocket and the door rollers. Turn the fly wheel by hand until the middle sprocket—intermittent feed sprocket—starts, but before it moves any distance stop and open the presser rollers and place the film upon the middle sprocket meshing it carefully with the teeth of the sprocket, and letting the presser rollers down upon it to hold it in place, the rollers pressing the film to the hubs of the sprocket teeth.

Now raise the carriage fully by means of the framing lever. Open the presser rollers of the bottom sprocket and place the film around the sprocket, but leave just loop enough to touch the back guard, putting the teeth of the sprocket properly through the film. Close the rollers, so that the film now lies between the bottom sprocket and the rollers, the rollers being on top.

Push the film through the two rollers in the bottom magazine, turning the handle of the motion head to give a sufficient slack to reach the arbor of the take-up device. Attach to the arbor in the usual way, take up the slack by turning the take-up reel by hand, then turn the crank a part of a turn to see that the take-up is working properly, and close the lower magazine door.

After everything is in place, turn on the light, but be sure that the fire shield is closed. When starting projection, press the main crank and handle somewhat toward the left. This will bring the friction clutch into action. Also notice before every projection of a reel that the automatic fire shutter is working properly. Should the fire shutter refuse to work, there is either oil or dirt in the friction clutch to which the chain is attached on the main shaft of the handle. Never oil the friction clutch. In case of dust or oil coming into this clutch, wipe it out clean and dry. Now open the door of the fire shield, turn the handle and proper projection may be made.

GENERAL NOTE

Before taking the instructions for any particular machine as final, remember that there are many general rules which apply to all machines, and these have been discussed under the subject of the motion head and motion-picture projection in general.

AUNTY LEARNS SHE HAS MARRIED A TRAMP
Scene from Photoplay, "What Happened to Aunty"
Courtesy of *Essanay Film Mfg. Co., Chicago*

MOTION HEAD

PART III

TALKING PICTURES

The histrionic stage holds a mirror up to nature. That is the text upon which a preliminary description of the art of the talking picture will be based. The motion picture reproduces, as a mirror would reproduce, the histrionic stage; the actors of the drama are voluble of lip and expressive of face and gesture, but they are silent. The motion-picture scene of the waterfall shows the tossing waves and the plunging masses of turbulent water, but the splash of the rapids and the roar of the cataract are not heard. In the motion picture of the rural summer landscape the trees may wave their boughs upon the picture screen and the atmosphere of the grove seems almost to pervade the theater, but the murmur of the breeze in the tree tops and the buzz of the cicada are not there.

The motion picture truly holds a mirror up to nature, but it is only an ordinary looking-glass giving back the scenes, but not the sounds. The talking picture promises nothing new from the picture screen, but promises to supply the missing sounds, to couple the senses of sight and hearing, and to make the reproduction of the subject complete, at least so far as drama and vaudeville may be concerned.

NATURE OF THE PROBLEM

To get a close understanding of the problem of the talking picture the experimenter may assume a position before a mirror, and, being in such position in fancy or in fact, he may talk, sing, laugh, or dance before it. If he should talk or sing, the lip movements would be reflected by the mirror exactly as produced by his lips. These movements he will see in the mirror. At the same time, he will hear his own voice, but not in the mirror or from the mirror. If he should dance, the faithful mirror gives back every movement to his eye, but does not give back to his ear the sounds of his feet upon the floor; those sounds are heard by his ears directly

Now let the experimenter bring into his service the motographic camera. Again, he may talk, sing, laugh, or dance. The mirror is replaced by the sensitive photographic film, which receives the light much as the mirror did, but which records it as received. By processes of photographic development and printing and then by projection, the motographic film is made to give its record to vision, long after the experimenter has ceased talking, singing, laughing, or dancing.

What is this projected motion picture, recorded by the motographic camera and the sensitive photographic film? Just what the mirror gave back—the scene but not the sound. The photographic film was sensitive to light but not to sound, and recorded light but not sound, ultimately reproducing its record in light but not in sound.

Recording Sound. The phonograph, or graphophone, is hardly older than the motion-picture camera. Like the motion-picture camera, the graphophone has a recording surface but the surface is of a different nature and the method of recording upon it is different. The camera record surface makes a record of light; the graphophone record surface makes a record of sound. Like the camera, the graphophone may be made to give back its recorded message in the language of the record, light for the one and sound for the other.

How easy it seems for the experimenter to procure both a camera and a graphophone, and to talk, sing, laugh, or dance before both of them and then have both of them reproduce their respective records at the same time, whereby not only the sight but the sound of the speech, song, laugh, or dance may be reproduced at will from the inert records for the entertainment of the experimenter or others. With the first experiment at this duplex making of records, the feature of synchronism will become a prominent and probably an inharmonious one.

Synchronism. When the experimenter stood before the mirror, he heard the spoken word at the same instant that he saw the lips in the mirror move. He heard the sound of the step of the dance at the same instant that he saw the mirrored foot strike the floor. But in the reproduction, such a difference! The graphophone begins the song before the pictured man upon the screen has opened his lips; or the picture shows the experimenter singing or dancing in a manner familiar to all theatergoers, and in the midst of the motion picture the graphophone begins a song or a clatter which seems to have no relation to the picture. Synchronism is lacking. The experimenter now has learned that his two records must start together, or in proper relation, and must keep together, for when they are only a second apart in time, they are more ludicrous than when so far separated that they seem to have no relation at all.

The graphophone has not been perfected for the minor sounds of nature. The human voice is about the limit for the sound record. Voices and musical instruments are the standard repertoire of the talking machine, other records being the exception rather than the rule. This limitation of the graphophone limits the combination sight-and-sound entertainment to dramatic and vaudeville incidents, dancing and singing.

The tremendous demand for motion pictures which do not talk, the large number of theaters projecting motion pictures as the principal part of their program, and the avidity with which the theater manager investigates novelties to please his patrons, all indicate that a successful talking picture with a reliable system of projection to maintain synchronism between picture and speech would meet with a royal welcome and bring a rich reward to its promoters. Thus it has become the dream of inventors to combine those two devices, the motion picture and the graphophone, successfully, but always the stumbling block has been synchronism.

Not only must the picture film and the talking record be capable of synchronism, but means must be provided whereby they may be kept in synchronism either automatically or with a minimum amount of skill on the part of the theater operators. Synchronism, therefore, must be considered in two phases: *first*, making the photographic record and the sound record in such relation that reproduction in synchronism is possible, and, *second*, reproducing them properly as intended in their manufacture.

If the graphophone record and the picture film must be projected at the same speed to keep them in unison or in synchronism as required, may not both be put in a single machine equipped with sound reproducer and a projecting lantern? In toys this is practicable, or in a home exhibition, but in a large theater the motion pictures are projected from behind the audience, passing over their heads to the picture screen and being appreciated by the audience only as rays passing from the screen to the eye. If the graphophone were located with the projecting machine for the pictures, the sound would come to the audience from behind, which would be unnatural. Instead, the sound must come from the front of the theater. This limitation compels the location of the phonograph at or near the picture screen, while the projection machine must be at the back of the theater.

Only by projecting the pictures upon the back of a translucent curtain and permitting the graphophone to talk through the curtain may the two devices be located together.

The two machines, motion-picture projector behind the audience and graphophone in front of the audience, may be kept together in speed by some relation of propelling or controlling means. It is in this feature that inventors have been most active, and it is in this feature that the differences will be found in analyzing and comparing the different "talking picture" machines and systems offered and to be offered upon the market.

Length of Records. Theoretically, there are no limitations of length of a talking picture, for the second talking machine may be started just as the first talking machine is stopped, and the third disk of the series may be placed upon the first talking machine to be started just as the second one has stopped. Likewise, with two projecting machines, the second reel of film may be started just as the first is stopped, and the first projecting machine then may take up the third reel just as the second is finished.

With a single talking machine and a single projecting machine, the limit is reached with the talking machine first. The maximum talking record in America is the 12-inch disk running five minutes. The 10-inch disk runs three to four minutes, while the "four-minute" cylinder record lives up to its name, running four minutes or longer. European records running fifteen to twenty minutes have been reported and will be of value in the talking-picture art when adopted for that purpose. Cinephone films are offered upon 10-inch disk records, each accompanied by 150 to 250 feet of motion-picture film.

The possibility of the longer talking picture is assured, for it has been done. As for long, continuous sound records upon a number of disks, there are already offered to the general public for use in private talking machines, records for the complete operas of "Faust" and "William Tell." These records may have motion pictures fitted to them, according to the methods of the manufacture of talking pictures, or records of equal length may be made from the same or other subjects, complete with picture films.

CLASSIFICATION

All of the suggestions as yet made for producing talking pictures may be brought under one of the following three classes:

(*1*) The two machines are driven from the same source of power and are so related to this source that their speed of reproduction is identical.

(*2*) The two machines are so related that one drives the other or controls the speed of the other directly.

(*3*) Index hands or the equivalent are provided for the two machines, and an attendant, by constant supervision, keeps these index hands in proper relation.

(*1*) **Unitary Machines.** In the unitary machine, the two machines, projector and graphophone, are built together and are driven by the same main shaft of the combined machine, which may be turned by a crank or motor of any kind. In such a device, it is necessary to be able to secure exact synchronism at the starting of the picture and sound records, or to provide some means of adjusting in order to enable the operator in charge to get his picture to catch up with his graphophone, or to permit his picture to slow down to let the graphophone catch up with the picture.

Long Main Shaft. An invention which places two machines in the first class is the system of providing a long main drive shaft under the floor of the theater, gearing it at one end to the graphophone and at the other end to the projecting machine. At the projecting machine end, a clutch should be provided, and if the start is not made in synchronism, so that an adjustment is required, the operator may throw out the clutch and turn the projector by hand faster or slower until he gets the picture in synchronism with the speaking record; then he may throw in the clutch again, and the main shaft, driven by a constant-speed motor of sufficient power, keeps the two machines in constant speed relation, projecting their two records at the same speed and in synchronism.

When a splice in the film passes, where a few images have been cut from the film in repairing it, the picture film will run ahead of the graphophone record and the operator must detach his projector from the main drive shaft until the two records are brought into synchronism again. A new film should run in synchronism from start to finish under this method of driving, but an old film which has many breaks and splices becomes harder and harder to operate

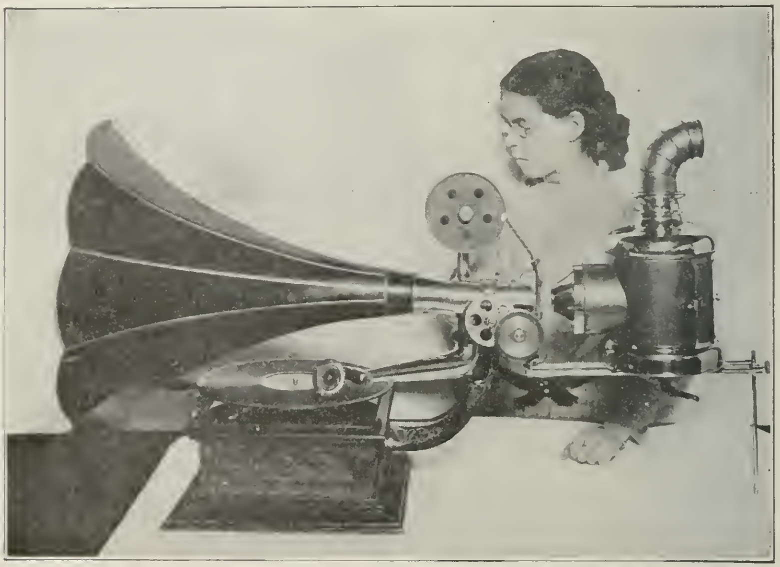


Fig. 105. The Photophone. A Unitary Talking-Picture Machine

in synchronism as its splices increase. A matter of three to six pictures cut from the film—one-fifth to two-fifths of a second in time of projection—is sufficient in most talking-picture records to render them very noticeably out of synchronism.

Synchronous Electric Motors. There is an electric motor which is called a *synchronous motor* because when carrying its load it runs always in exact accordance with the speed of the dynamo which is furnishing the electric current for driving the motor. It is a motor operated by an alternating current, and its speed always is proportional to the speed rapidity or frequency of alternation of the current which drives it. When two such motors, just alike, are placed in service upon the same power circuit, driven by alternating current from the same central station electric dynamo, it follows that each will run at exactly the speed of the other. With one such motor driving the graphophone and another upon the same power mains driving the projecting machine, the speed of the record of the graphophone and projecting machine will be identical, proper speed gearing to the motors being provided. Any slight change in speed of the electric generator at the power station which is supplying the current for the motors, which of course would result in a slight change in the frequency of the current upon the power mains, is equally effective upon both the graphophone and the projecting machine, so that the two machines always move in unison, keeping the reproductions of their records in synchronism, if the records have been made properly.

Illustration. In the unitary machine, shown in Fig. 105, the motion head of the projector portion of the apparatus is built upon the support for the graphophone horn. The moving parts of the motion head are driven from the graphophone motor which turns the flat disk record under the reproducing needle of the talking machine. It is necessary only to set the graphophone needle to a marked point upon the talking record disk and to bring a marked picture image into the film window of the motion head, then start the motor.

To produce a compact combination device without permitting the horn of the phonograph to interfere with the beam of light of the projected picture, the lenses are arranged to project the picture through the horn, as shown in Fig. 105.

In this device if the motion head be disconnected from the graphophone motor, a crank may be attached to the motion head and the skill of the operator then may attain and maintain a synchronism which approaches perfection only by the degree of skill of the operator.

Two machines driven by the same source of power are shown in Fig. 106. The source of power in this instance is the operator's arm turning the crank in the projection room at the upper left-hand corner of the figure. The crank is attached to one of a pair of bevel gears in the operating room, and thus drives the vertical rod extending down through the floor of the operating room to a point below the floor of the theater. There, it transmits its power to the long horizontal main shaft extending under the floor of the theater to a point under the graphophone. The graphophone takes its power from this long horizontal shaft by means of a short connecting vertical shaft. Thus the projecting machine and the graphophone are driven by the same crank through an arrangement of gear wheels and shafts.

Any variation in the speed of the graphophone will change the pitch of the sounds being produced, a result which cannot be permitted in reproducing musical records, and which would be very

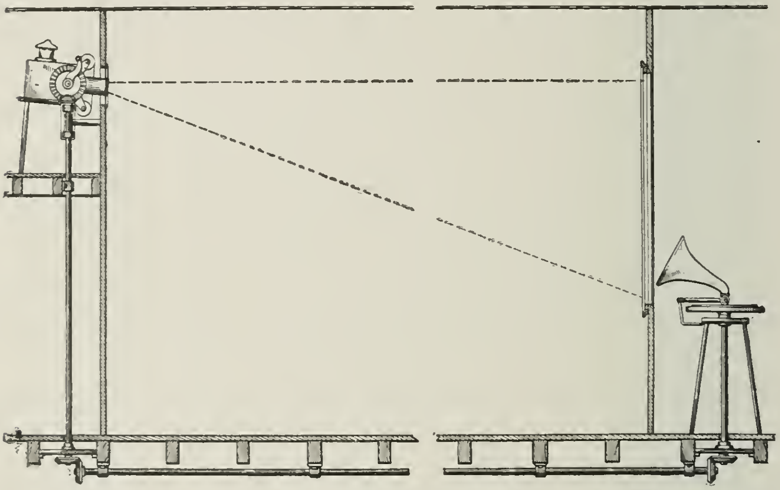


Fig. 106. Talking Picture Reproduction by Two Reproducers Driven from a Long Power Shaft

objectionable in any sound record. On the other hand, the motion pictures must be projected at about the speed for which they were intended when made. This distinction exists, however, that while a small variation may be permitted in the speed of the motion pictures, no variation at all should be permitted in the speed of the graphophone reproduction. Hence, the graphophone must be driven at a speed as nearly constant as can be obtained by an acceptable motor, and the speed of the motion picture must be varied to bring the two reproductions together whenever for any reason or by any accident they lose their relation of synchronism.

A splice upon an injured film will cut out a few images. Whenever this splice in the film passes through the motion head, the motion-picture film will begin to project its picture record ahead of the sounds from the graphophone, and the projector must be slowed down in speed until the graphophone catches up. Should the graphophone needle "jump a thread" or by any accident or a defect in the record fail to follow the record accurately, the projection operator must turn the projector faster or slower to vary the speed of the motion picture until the two records again are being produced in synchronism. It will be seen that in Fig. 106, to adapt the arrangement to practical work in a theater, the handle must be geared permanently to the shafting, and the motion head of the projection machine must have such a relation that it may run slower or faster in order to be capable of adjustment for synchronism.

Fig. 107. Graphophone for Talking-Picture Reproduction, Sending Current to Distant Projecting Motor through Electric Cable

(2) **Dependent Machines.** In this class of reproducing mechanisms for talking pictures, one machine must drive the other, or must control the other. As the variation in speed due to control, if any, must be impressed upon the picture projector and not upon the graphophone, the problem resolves itself into a constantly-driven graphophone either driving or controlling the picture projecting machine. Such a pair of dependent machines is shown in Figs. 107 and 108, the former showing the graphophone, and the latter, the picture projector motor.

The machine illustrated is one brought out in Paris and invented by Captain Couade. The crank seen in Fig. 107 is the crank for winding up the motor of the graphophone, and not for turning the graphophone directly. This graphophone runs in the usual manner, and may be quite an ordinary type of talking machine, with the addition of a commutator for electric current which changes a constant potential to a system of intermittent potentials upon different circuits, the relation of the potentials produced by the commutators of the graphophone being likened to the related potentials of a three-phase alternating current. The electric commutator is inside the graphophone cabinet, the electric terminals and switches being seen in the figure upon the outside of the cabinet. The wires which lead from the graphophone downward carry the electric potential impulses created by the graphophone commutator. In Fig. 108 is shown the motor for driving the motion-picture projec-

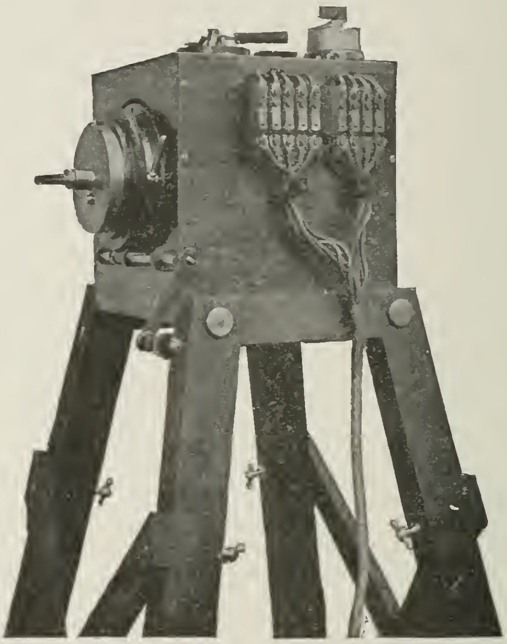


Fig. 108. Motor for Picture-Projecting Machine for Talking Pictures, Driven in Synchronism with the Graphophone by Current Received Over an Electric Cable

tion machine. This figure does not show the projection machine, nor is it necessary to do so, since any projection machine may be used to project the picture film, provided only it is coupled to this special motor and driven by that motor at exactly the speed which the graphophone dictates by means of its electric commutator. The electric cable rising from the bottom of Fig. 108 to terminals upon the side of the motor is connected at its other end with the commutator of the distant graphophone, located near the picture screen of the theater.

RAWHIDE UNDER PROCESS OF REFORMATION

Scene from Photoplay, "The Redemption of Rawhide"

SCENE FROM PHOTOPLAY, "THE WAGER AND THE WAGE EARNER"
Courtesy of *Thomas A. Edison, Inc., Orange, N. J*

In operation, the motion-picture film is placed in the film gate and framed with a marked image in the film window. The needle of the graphophone then is placed upon the record disk at a marked point. These two marked points, one on the picture film and one on the sound record, were obtained in manufacture and placed upon the records when the records were made. They are points to which the records are in unison in time with reference to the light and sound of the subject.

The phonograph now is started and driven in the usual manner. The motion head of the projection machine, driven by the motor. gains speed as the phonograph gains speed, until both are running fully. If the projection machine is provided with an automatic fire shutter, the shutter will be lifted and permit the projection of the picture upon the screen as soon as sufficient speed has been attained.

In this device, the motion-picture projector is started by the graphophone, and it is run with the graphophone, stopping with the graphophone. The power for running the motion-picture projector is not created by the graphophone, nor by its motor, but it is so controlled by the commutator of the graphophone as to drive the motor and the picture machine at the required speed. The motor is so constructed as to be unable to turn under the influence of any direct current which may leak to it through the graphophone commutator while the graphophone is at rest. The operator at the projection machine must note any lack of synchronism and correct it, after which the records will stay together.

(3) **Dial=Regulated Machines.** In this class of reproducing devices for talking pictures, the talking machine and the picture machine are separate, and each has an index hand. The index hands need have no direct relation to each other nor any direct connection with each other, but each serves to show the speed at which its associated machine is being driven. The graphophone being driven at a constant speed, its index hand will revolve at a constant speed, and the projection machine operator then must turn his crank at such speed as will make the picture machine index hand keep up with the pace of the graphophone hand, and not run ahead of it.

Greenbaum. In Fig. 109 is shown a diagram of the system and some detail of the apparatus of the Greenbaum device. In the figure, at the upper left-hand corner, is shown a commutator upon a shaft which is mounted in connection with the shaft of the motion-picture projector. At the upper right-hand corner of the figure is shown a similar commutator which is mounted upon a revolving shaft which is associated with a shaft of the graphophone. The device forming

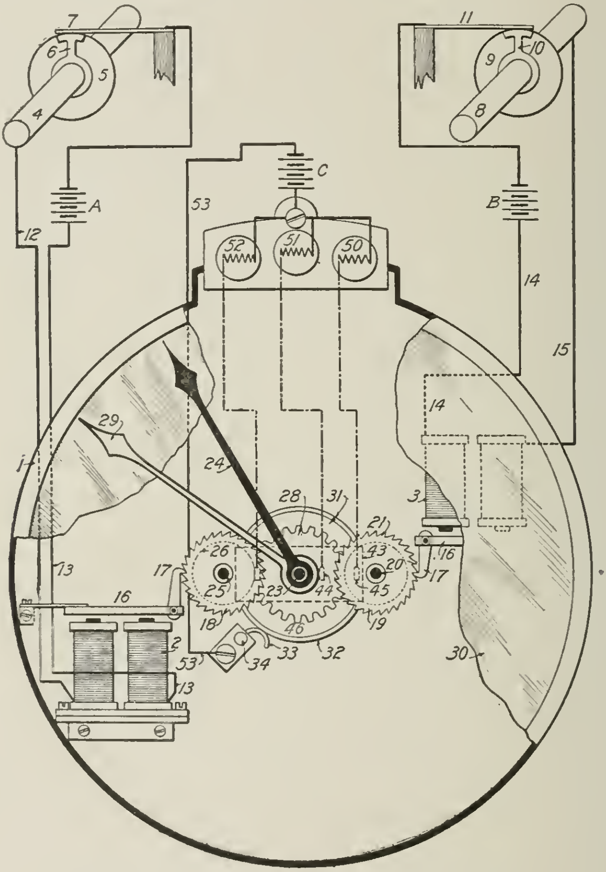


Fig. 109. Greenbaum Mechanism for Synchronizing Talking Picture

the lower part of the figure is a dial which is mounted in the operating room, in front of the operator who is turning the crank of the motion-picture projector. Upon the dial are seen two index hands, *24* and *29*. The hand *24* is driven by the picture projector and the hand *29* is driven by the graphophone. When the two machines are running in synchronism, the two hands will maintain a constant angle between them, preferably being together, that is, the hand *24* should cover the hand *29*. By reason of splices in the film, or by accident, the hands may become separated, in which case the angle between them must be kept constant by the projection-machine operator.

Electric incandescent lamps also are provided—as shown by the circles 50, 51, and 52 in the figure—and are so arranged that lamp *51* will glow when pictures and talking record are in unison; lamp *52* will glow if the pictures are behind time; and lamp *50* will glow if the pictures are ahead of the talking record. The lamps, as well as the hands, serve to guide the projecting operator to keep the two records in synchronism.

The mechanical arrangement of parts in the Greenbaum device is as follows: In the case *1*, the two electromagnets *2* and *3* are mounted. Electromagnet *2* is connected by electric wires *12* with the electric commutator device of the shaft *4* pertaining to the projector, in such manner that every time the commutator of the shaft *4* closes the electric circuit an impulse of electric current will flow from the battery *A* through the wires *12* and the commutator and the magnet *2* to cause the armature *16* of the magnet *12* to be attracted. This, by the action of the pawl *17*, drags the ratchet wheel *18* down one tooth; this ratchet wheel in turn by a pair of gear wheels drives the shaft of the hand *24*, moving the hand *24* a short step over the dial *30*. One such step of the hand *24* is made for each revolution of the shaft *4* of the projector, hence the speed of the movement of the hand *24* is a measure of the speed of the projector.

In like manner, electromagnet *3* is connected by electric wires *14* and *15* with the electric commutator device of the shaft *8*, pertaining to the talking machine, in such manner that every time the commutator of the shaft *8* closes the circuit an electric impulse will flow from the battery *B* through the wires *14* and *15* and the commutator and the magnet *3* to cause the armature *16* of the magnet *3* to be attracted. This by the action of the pawl *17* drags the ratchet wheel *19* up one tooth; this ratchet wheel in turn by a pair of gear wheels turns the tubular shaft of the hand *19*, moving the hand *29* a short step over the dial *30*. The hands *24* and *29* move in the same angular direction, and when the records are being rendered in unison they move at the same speed.

It is necessary, in starting the devices to render a talking picture, to place the film in the motion head with a marked image in the film window, to place the needle of the talking machine upon a marked place in the record, then to place the two hands of the indicator together. After that, if the hands are kept together, the records will be kept together as the records are reproduced. The passing of splices where images have been cut from the picture film will cause the hands to separate if synchronism is maintained by the operator, since the projection operator must slow down his machine to regain synchronism, after which the relation of the hands is maintained at the new angle.

Cinephone. The cinephone system of talking-picture production will appeal alike to the projection operator and to the practical theater manager, and for the same reason, namely, that it has a minimum of special apparatus in the theater, and it requires the least specialization of skill on the part of the projection operator.

The cinephone as offered to the public is in substance only an attachment for a well-known type of talking machine. As built it is a quick-starting talking machine having an unusually heavy spring which permits it to obtain its full speed and volume of sound almost instantly upon the release of the ordinary brake which sets the disk record revolving. It may be used for ordinary disk records for entertainment between pictures, or for illustrated songs, without the cinephone motion-picture films, which in connection with the talking machine produce the talking pictures.

The cinephone talking machine stands at the side of the picture screen and faces the audience and the projection operator. It has an illuminated dial upon its front face, upon which there is an illuminated revolving hand. The course of the hand is marked by four green bullseye lamps, readily discernible by the projection operator in a darkened auditorium, even at a distance of two hundred feet.

The illuminated dial and hand are for the purpose of registering the exact speed at which the talking machine is operated. A similar dial and hand are photographed into the motion-picture film, the hand of the motion-picture film traveling over a circle which is marked by four white bullseye spots upon the picture screen. This second dial and hand appear in the lower left-hand corner of the film picture and of the screen when the picture is projected upon it.

As the picture is shown, the dial hand in the screen and the dial hand upon the front of the talking machine both move in the same direction and at the same speed. The projection machine is operated at a speed calculated to keep both dial hands at the same point upon the dial circumferences at all times. So simple is this, that anyone can be taught to produce cinephone synchronism in a few moments.

Any projection machine already in use may be used under this system of synchronism and any ordinary operator can master the additional detail quickly and show a finished talking picture.

There are no connections, electrical or otherwise, between the cinephone talking machine and the picture screen, nor between the cinephone talking machine and the projection machine. The operators required are the projection-machine operator and the pianist or other musician or regular attendant of the theater to make the change of records and rewind the talking-machine motor, and to start the talking machine when the starting flash is received from the picture projector. It is the intention of cinephone design that the number of employes of the theater need not be increased, and that no special skill be required of any of them.

MANUFACTURE

The theoretical method of recording action and speech, by locating a recording graphophone and a motion-picture camera properly near the speaking actor, has limitations. The graphophone must be near the speaker, or it will not record the speech, while the camera requires some intervening distance in order to secure a proper rendering of the picture. Yet the graphophone must not appear as an object in the picture obtained by the camera.

Small Subjects. A very delightful and thoroughly successful talking picture, or better "singing" picture, is that of a canary bird singing in its cage. The actual area pictured by the camera is only about a square yard, with the bird near the center, so that the graphophone recording horn could be brought within 18 inches of the bird without appearing in the picture made by the camera. In this manner, the two records could be made simultaneously, and when reproduced they are capable of absolute unison when properly synchronized and uniformly driven at the proper speed.

A talking picture of a "laugh" in which the laughing face is taken by the camera at close range, to fill the entire space of the picture image, being then projected to fill the entire picture screen, may be made in the same manner. Even in the case of a monologue by a single actor, where the actor standing before the camera fills the picture image space to the top line, the limit of the field of the camera may be determined very accurately and the recording grapho-

Fig. 110. Producing the Talking Record for a Talking Picture

phone horn may be placed just above the limit of vision, that is, just above the picture as projected upon the screen.

Large Subjects. In producing a talking picture where several actors are involved, the method of manufacture is to make the talking record first, and then fit a motion picture to it. To do this, the actors are well drilled in their parts, so that they will be able to produce the performance twice, once in sound for the sound record and once in action for the picture record.

The actors being thus trained, the sound record is produced without any reference to what the appearance of the actors may be while producing the record, the end desired being only that the best possible sound record be obtained.

A group of actors producing a sound record is shown in Fig. 110. They are standing compactly grouped, facing the recording graphophone. The stage director stands coatless above them. In Fig. 111, the next step of the process is shown, namely, that of training the actors into unison with the sound record already produced. In the foreground is seen the horn on the talking machine. It is rendering the sound record. Before the horn stand the stage director and a group of the actors. The actors are repeating the words which they

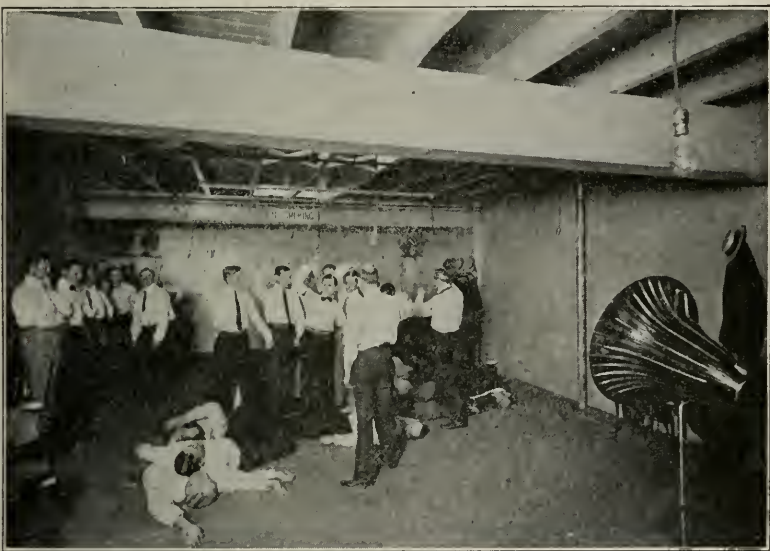


Fig. 111 Drilling the Actors before the Graphophone to Attain Unison with the Talking Record before Making the Picture Record of a Talking Picture

used in making the sound record, repeating them in unison with the talking machine, and at the same time suiting the actions to the words. As yet the camera has not been brought into use, for the sound record may be made indoors, and the rehearsal for action may be made indoors as well, but the making of the picture must be done in the field before a suitable background or in the studio in a proper stage setting.

Talking=Picture Camera. The combination camera and talking machine for the final step, namely, the making of the picture record, to fit the talking record, is shown in Fig. 112. At the left is the reproducing graphophone; at the right is the motion-picture camera. Both are mounted upon tripods, for use in field or studio. Connecting the two machines is a driving shaft, and upon the tripod with the camera is mounted an electric motor for driving the shaft. This combination machine is started, the actors act and speak in unison with the talking machine, and are photographed by the camera. Even the words of the talking machine must be repeated in unison with the machine, that the lip movements of the actor in the motion picture may be synchronous with the spoken words of the talking machine.

The photographic negative is developed and prints are made. The starting point now is marked upon the sound record and upon

Fig. 112. The Recording Motion-Picture Camera Coupled to the Reproducing Graphophone for Producing the Picture Record of a Talking Picture

the picture film, and the two records are ready for delivery to the theaters for the production of talking pictures.

REPRODUCTION OF TALKING PICTURES

Operation of the Cinephone. The picture screen and talking machine of a theater with the cinephone in operation are shown in Fig. 113. Note the dial upon the talking machine, and the similar dial in the lower left-hand corner of the picture upon the screen. Note

Fig. 113. The Cinephone in Operation

also that the hands upon the two dials occupy the same relative positions.

Starting in Synchronism. The pianist assists the projection operator by managing the talking machine. The talking machine is turned slowly by the motor or by hand until the index hand is in an upright position, pointing to the top lamp of the four which surround its dial and which appear in Fig. 113 as four black spots, above, below, to the right, and to the left, respectively, of the dial on the front of the talking machine. The disk record then is placed on the carrier with its marked point under the needle. A groove is cut in the disk to guide the needle to the starting point of the record. The motor of the talking machine is wound and the talking machine is ready for action.

During this process, a small incandescent lamp has been burning upon the top of the talking machine; when all is in readiness, this lamp is turned out by the pianist as a signal to the projection operator in the operating booth that the talking machine is in readiness.

The projection operator threads his leader through his motion head in the usual manner, there being no special marked points to be observed, and begins projecting the film at the cinephone speed of eighteen pictures per second, or about sixty-six feet per minute—a speed one-third greater than the usual picture speed. All initial leader and title having passed, and the portion of the picture having been reached where the talking machine is required, there appears upon the picture screen, for a fraction of a second only, the words, "The Cinephone." This is the "starting flash," usually stained yellow and, therefore, called the "yellow flash," which is the signal for starting the talking machine. The pianist, who has been waiting with hand on starting brake of the talking machine, draws the brake away from the record carrier.

The talking machine starts at full speed, and the index hand of the talking machine also starts revolving. At the time of the starting flash, the index hand of the picture film is vertical—note the lower left-hand corner of Fig. 113—and so corresponds with the vertical position of the index hand of the talking machine.

Maintaining Synchronism. The operator turns the projecting machine at the proper speed to keep the two index hands together, and the two records will remain in synchronism through the entire picture. The cinephone speed is faster than the ordinary picture speed, the cinephone film running fifteen minutes to the reel while the ordinary film runs twenty minutes to the reel, but the ordinary projecting machine will stand successfully the strain of the somewhat higher speed.

The index hand for the picture screen dial is photographed into the cinephone picture film, and requires nothing special upon the projection machine for the projection of the index hand. Splices are self-correcting in the cinephone film, because when a few images are cut out of a strip of film, the index hand for those images is cut out also.

The index hand makes one revolution upon the picture screen for every 14 feet of picture film. This gives the hand a speed of revolution of about four and three-quarters turns per minute, or one turn in about thirteen seconds, the talking-machine hand having the same speed also. If, by some accident, the projection operator is compelled to cut out a piece of cinephone film, say even as much as 3 feet of it, the splicing of the film will cause a jump in the pictures which will take them out of synchronism with the talking machine. In such a case, the index hand upon the picture screen will appear to jump also, just the same as any other moving object upon the picture screen. For a 3-foot loss of film, the index hand will jump a quarter of a revolution, and be a quarter turn ahead of the talking-machine index hand; the projection operator then slows down his motion head until the talking-machine hand catches

Fig. 114. A Specimen of Cinephone Film

up for the loss, and within ten seconds the synchronism will be restored for the loss of a yard of film. Ordinary splices, where but from one to six of the little pictures are lost, pass without notice, being almost instantly and unconsciously corrected by the operator, whose eye is constantly upon the two hands.

In case the talking machine, because of a defective machine, a defective needle, or a defective record, should "jump a thread," the projection operator will notice it, turning either faster or slower until synchronism is attained by letting the index hands separate, then turning at the standard speed until the end of the picture, keeping the index hands steadily apart at the distance caused by the loss or gain of the talking machine. With a talking-record disk driven at seventy-eight revolutions per minute, the usual speed for Victor records, a loss or gain of a thread upon the record makes a difference of one-sixteenth of a revolution of the index hands. That is to say, the gear between the revolving record and the index hand is about sixteen-to-one.

The excess speed of the cinephone film, 66 feet per minute instead of 50 feet per minute for standard projection, will enable the operator to turn his motion head for cinephone film at three-quarter speed without causing an objectionable flicker upon the picture screen, thereby enabling the talking record to again come into perfect accord with the picture film, that is, enabling the index hand of the talking machine to catch up with the index hand of the picture screen.

A specimen of cinephone film is shown in Fig. 114, showing the index dial and hand photographed into the lower left-hand corner of each of the images.

COLORMOTOGRAPHY

Color photography with the fixed camera has been an accomplished fact for several years, but the production of colored motion pictures, in the colors of nature, by photography direct from nature with color-sensitive photographic films, has only lately reached two solutions, one of which is called the Urban-Smith process and the other the Friese-Green process. Both of these have been exhibited publicly. Other processes are promised, but the promises are as yet unfulfilled.

URBAN-SMITH PROCESS

The motion picture itself, the black-and-white kind, utilizes the persistence of vision for the production of motion in the picture, simulating the motion of the subject photographed. The Urban-Smith process utilizes the persistence of vision still further, causing it to produce also color in the picture simulating the color of the subject photographed. Obviously, it would be possible easily to reproduce in blue upon the picture screen a picture which has nothing but blue in the subject photographed; or the same is true of green if the subject had nothing but one shade of green in it; but when the subject has both blue and green, and perhaps red and yellow as well, how shall these colors be preserved separately and combined upon the screen when projected?

The Urban-Smith answer to this question is that they may be photographed separately and then thrown upon the screen so rapidly one after another that the eye of the spectator (by the persistence of vision) sees all of them at once. This fundamental principle of recording and reproducing the colors of nature has been worked out in a practical form for motion-picture theaters, and has been named "Kinemacolor." The working colors of the photograph have been reduced to two, green and red (or orange). The film when examined before projection appears quite the ordinary black and white film; the color is given to the light rays after they have passed through the film. The pictures are projected at thirty-two per second, or 120 feet of film per minute, a speed about two and one-third times as fast as the usual projection of ordinary motion pictures.

Making Kinemacolor Film Pictures. The camera is provided with a double shutter, having two windows, making sixteen revolutions per second, while the sensitive film is shifted thirty-two times per second. This corresponds to the number of exposures, since the shutter with its two windows makes two exposures upon the film for every revolution of the shutter.

The film is sensitive to light of all colors, and the shutter carries in each of its windows a sheet of colored gelatine, one window being colored green and the other window being colored red or orange. Thus, when the strip of sensitive photographic film has been exposed in such a camera, and subsequently developed into a negative, it has upon it one picture taken through a green window with green light only, and the next picture taken through a red window with red light only, and so on alternately for the entire length of the film. In addition, a spot is printed opposite each green-light picture to identify the green-light pictures from the red-light pictures, for all of the images in this negative film are merely black-and-white, without any traces of color whatever.

From this negative, a positive print is made, exactly as for a black-and-white picture. The guide spots for the green-light pictures are transferred to the positive print and serve to identify the green-light pictures in the positive. The Kinemacolor film for the projection of motion pictures in natural colors now is complete and ready for the Kinemacolor projecting machine. No coloring whatever is found in the film. Then how are the pictures to be projected in color?

Production of Color. It is generally known that all of the tints and hues of nature can be reproduced by a correct combination of three elementary colors in proper proportions. Red, yellow, and blue usually are used as a set of elementary or primary colors, but orange, green, and violet serve as well.

Printing presses turn out daily numberless pictures in colors, calendars hang upon the walls, and picture postcards travel through the mails in flocks, bearing the colors of nature. Yet examine them, and the largest number of them will be found to have met the printing plate but three times, once for each of three colors, usually red, yellow, and blue, yet each shows a wide variety in number of colors and a wide variation in tones of each color. It is by the combination of the primary colors in proper proportions that these effects are attained, and the same principle is used on the Urban-Smith process of color motography.

On the postcard, the colors will be found to be made up of numberless small spots of the primary colors, intermingled, so that the eye sees none of them separately, but all together, the colors being mingled in the eye. The Urban-Smith process also throws from the screen to the eye the different primary colors in different quantities from the same spots on the screen, and the colors mingle in the eye by the persistence of vision to produce a wide variety of shades and tintings.

Flag in Color. There is presented in Fig. 115 a reproduction of a Kinemacolor photograph of the British flag, a flag which has a blue field crossed by red stripes, with lines of white bordering the red stripes and separating the red and blue. The spot for identifying the green-light picture is visible in the margin between the perforations, opposite the second and fourth pictures, counting from the top of the figure. The first and third pictures, counting from the top, are the red-light pictures.

For purposes of study, consider that these small pictures are cut apart, that the first picture is placed between two lantern-slide cover glasses of clear glass and projected upon the picture screen, and that the second picture is placed similarly between the two other cover glasses of clear glass and projected from a second lantern upon the same screen and upon the same spot of the screen, so that the two flags from the two lanterns will be focused upon each other upon the picture screen. The audience will see but one flag, not realizing that the one picture is projected from two lanterns.

Fig. 115. A Kinemacolor Flag

Note that the second lantern has the picture with the green-light spot, therefore, it has the green-light picture, so slip a sheet of green gelatine over the slide, and at the same time slip a sheet of red (or deep red-orange) gelatine over the picture in the first lantern. This produces a beam of green light from one lantern and a beam of red light from the other lantern, but when they fall upon the picture screen on the clear space all around the flag pictures they will both be seen by the eye at once and the combination will give a white light, or nearly so; hence the flag will be seen upon a white background with the colored beams of light, just as it was before the colored gelatine sheets were put into the lanterns.

The same is true of the lines along the edges of the stripes or cross-bars of the flag, but with the bars themselves it is different.

Note that the top image, or red-light image, is clear in the cross-bars, while the second image with the green-light spot is dark in the cross-bars. Then the red-light lantern, with the red gelatine color screen and the red-light image of the flag, will project red light upon the cross-bar portion of the flag, but the green-light lantern, with the second or green-light image, which is opaque in the bars, will be unable to project any green light upon the bars of the flag on the screen to change the red light to white, hence the bars of the flag will be seen red by the audience. In the space of the blue field of the flag, a little red and a little green light will be projected through the half-tone of the picture film, combining to produce the blue of the flag.

Alternate Projection. In the Kinemacolor projecting machine, the red-light flag and the green-light flag are not projected at the same time, as was considered with the two lanterns for purposes of analysis and study, but they are projected one after the other so rapidly that the eye retains the red picture while the green picture is being projected, and then in turn retains the green picture while the next red picture is being projected, thus actually seeing both pictures at once by the principle of persistence of vision.

The beam of light from the picture film is colored red and green alternately by a shutter upon the projecting machine similar to that in the camera with which the pictures were taken. The shutter has two windows, one of which carries a piece of red or orange gelatine and the otner of which carries a piece of gelatine colored green. The green gelatine is in front of the lens while the green-light image is being projected and the red gelatine is in front of the lens while the red-light image is being projected. In this manner, the different images are projected with the color of light which made the negative in the camera, and the light given to each portion of the screen is of the same color and density as that which made the corresponding portion of the negative, which is to say, the same as that which was given to the lens or to the eye of the observer by the actual scene motographed. Because of the speed of projection and the principle of the persistence of vision, the red-light pictures and the green-light pictures are blended together in all portions of the picture screen at once, so that the eye sees the view as it appeared before the camera, with all its colors and gradations of color and light and shadow in all its different parts.

SCENE FROM PHOTOPLAY, "ONE OF NATURE'S NOBLEMEN"

JOSE STEALS THE GUN

Scene from Photoplay, "The Spanish Love Song"
Courtesy of *G. Melies Company, New York*

Fig. 116 shows a reproduction of a water scene motographed in Kinemacolor film.

Kinemacolor Machines. The Kinemacolor film is made to be projected at a speed two and one-third times as great as ordinary black-and-white film. No ordinary machine will stand the strain of such a speed of projection, and a special Kinemacolor projecting machine has been built for the work. The machine should be run by a motor, the power required to drive it at its high speed being almost too great for the arm of the operator, although a short length or a single reel of Kinemacolor may be turned through by hand. A reel of one thousand feet of Kinemacolor film runs but eight minutes on the picture screen. Let any operator try to turn a full reel through an ordinary projecting machine in eight minutes and an idea will be had of the power and speed required of the Kinemacolor projector.


Fig. 116. A Kinemacolor Water Scene

The Kinemacolor projector is fully adapted for the projection of ordinary black-and-white, 50-feet-per-minute film, merely by removing the color screen, or shutter having the colored windows, and then turning the machine at a proper rate of speed for fourteen images per second instead of thirty-two.

All of its parts are similar to the generally known projecting machines of America, except the intermittent mechanism for the shift of the film, and the removable color shutter. The machine when equipped for color projection carries two shutters, the simple shutter for black-and-white pictures being left on when the additional color shutter for Kinemacolor pictures is added. A view of the operating side of the motion head is shown in Fig. 117 and a view of the color screen or color shutter is shown in Fig. 118.

Intermittent Mechanism. The intermittent sprocket of the ordinary type of projecting machine is replaced by a device of the beater class, shown at *66* and *67* in Fig. 117. This beater cam pulls slack into the bottom loop of the film at every revolution, drawing the film down through the film gate just as the intermittent sprocket does in the usual type of American machine.

In threading, the film is carried over the beater dog as it would be carried over the intermittent sprocket, except that there are no teeth to enmesh, and no presser roller for the beater dog. The course of the film through the motion head is seen very clearly in Fig. 117. The upper loop between the upper steady feed sprocket and the film gate should be rather small when the beater dog has just drawn the film down.

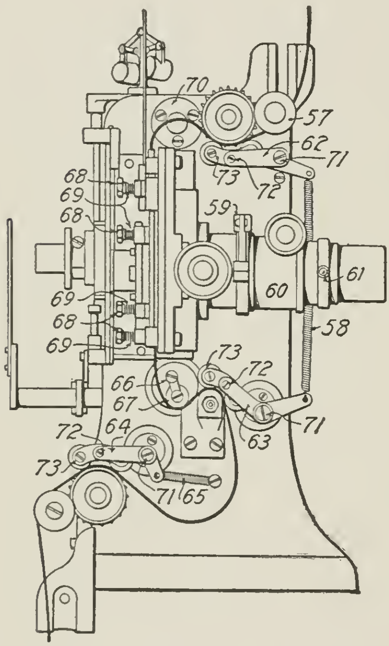


Fig. 117. The Kinemacolor Motion Head

Adjustment of Color Screen. The color screen is made of thick sheets of gelatine clamped between steel frames, as shown in Fig. 118. Not only is the steel frame capable of being removed from the shutter shaft which carries it upon the projecting machine, but the sheets of gelatine are capable of being removed from the frame.

The red gelatine is used in a single thickness, but the green gelatine is used in two parts, first a single thickness covering the whole of the green window, then another piece of green covering the middle portion and giving a double thickness in the middle of the window. The object is to permit an adjustment of the relative volume of light in the red-light and green-light pictures, or in the red-light and green-light beams of light thrown upon the screen by the motion head through the color shutter when there is no film in the film window. When the color shutter is adjusted properly, and the Kinemacolor motion head is turned rapidly with no film in the window, the picture screen should appear white. This is an adjustment that the Kinemacolor operator must make.

The color of the red gelatine in the color shutter is a standard and, therefore, should not be changed. Were the color shutter put in the machine with only a single thickness of green gelatine, the screen would be greenish white when the motion head is turned rapidly without a picture film in the film gate, and all pictures when projected would take that greenish tint. On the other hand, were two thicknesses of the full size of green gelatine placed in the shutter, the screen would appear a light orange.

The size of the smaller piece of green gelatine must be adjusted until the screen appears a clear white. This is the best adjustment attainable, and when done has adjusted the color shutter to the color

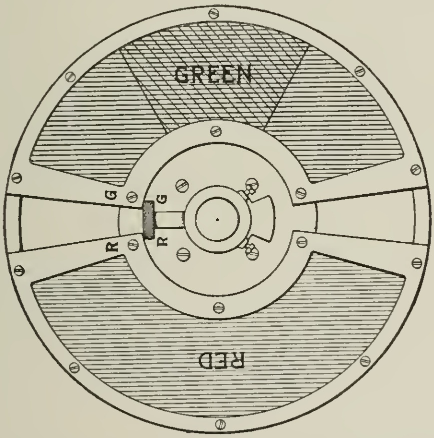


Fig. 118. The Kinemacolor Color Shutter, Showing Red-Light Window, Green-Light Window, and Open Spaces for Blue Light

of the arc lamp. The adjustment should be made with the arc of medium length, not just after feeding, nor just before feeding is needed. Nor should the color of the screen be judged just after looking at the arc, for the arc will have blinded the eye and will have rendered it impossible to judge the color of the screen.

The color shutter is so adjusted upon the shaft which carries it that either red light or green light will be admitted to the picture screen through the colored gelatine windows when the lens of the motion head is opened by the opaque shutter. The open slits of the color shutter will pass the lens while the opaque shutter has the lens closed. By inspection of the opaque shutter, it will be seen that the shutter is not black, but a dark blue, thus supplying to the picture screen a third tint through the open slots of the color shutter to correct some of the tints of the Kinemacolor picture when projected.

Framing. The Kinemacolor projecting machine has a larger range in framing than the ordinary machine, since it is necessary to frame to either one of a pair of pictures in the strip of film. Thus an image may be accurately centered in the film window when the film is at rest between shifts of the intermittent movement, and when the shutter therefore is open, but if the image be the red-light image and the shutter window just then before the lens be the green-light gelatine window, then the film must be framed forward or back one whole picture image to bring a green-light image into the film window for the green gelatine of the color shutter.

Framing Titles. To assist in the proper framing of the pictures for color before the actual pictures begin to be projected upon the screen, the titles are made in the green-light images only, the red-light spaces being left of blank, black film between the green-light title images.

The title, therefore, must be framed to green as well as framed to center in the film window and upon the picture screen. If the title comes red-light upon the screen, frame it up or down a full picture, making it green. The picture which follows then will come in its proper colors.

Splicing. Owing to the hard usage of the film because of its projection at such a high rate of speed, the splices must be strong. The splices should be a half-picture or two full sprocket holes, instead of a quarter picture or only one sprocket hole, as is the case with ordinary film. By the beater type of shift mechanism, there is no intermittent or high-speed sprocket. All of the sprockets are steady feed and reasonably low speed, hence able to negotiate the less flexible splice better than the sprocket shift.

Splicing for Alternation. This is splicing for color. The pictures in the unbroken film come red-light, green-light, red-light, green-light, and so on, and this order must be preserved when cutting out a bad spot in the film and splicing up. Always cut an even number of images. Cut out one and a half and lap a half, thus making a cut of two images, or four, or six, as may be necessary. If a single red-light image were cut out, it would leave two green-light images together. When that point would be reached in the projection of the film, the second of the green-light images would get the red-light window, the next or red-light image would get the green-light window of the color shutter, and so on, every image getting the wrong color from the color shutter. Every object in the picture upon the screen showing any color at all would change its color. The trees would turn red instead of green, the sky orange instead of blue. The picture upon the screen would be spoiled until the projection operator could notice the condition and frame the film backward or forward one whole image.

When it is found that a film changes thus in projection, a splice improperly made will be found at the point where the change occurs. This should be cut and respliced, taking out only one image, to change the film back to the proper alternation of red-light, green-light, and so on.

The green-light spot opposite the green-light images, shown in Figs. 115 and 116, will aid in making the splices correct for color, and will aid in inspecting any splices which may be found in a film not yet projected. In some Kinemacolor films, the green-light spot is not printed photographically, but is made by a spot of green dye or pigment upon the gelatine of the film, or by a short green line upon the margin opposite the green-light picture.

In the absence of either photographic spot or green mark, the alternation of pictures still may be observed in most Kinemacolor films by the comparative density of the images, or of some particular portion of the images. If there are green trees, they will be light and dark in alternate pictures, being lighter in the green pictures. The sky if blue will be lighter in the green pictures, but if gray or cloudy it will be of about the same density in both. Perhaps a dress or house may give the light-dark-light-dark alternation, and in splicing it matters not which is light and which is dark, so long as the alternation of light-dark-light-dark for the series of pictures is continued properly over the splice.

In Fig. 115, the bars of the flag give the light-dark alternation, being light in the red-light picture, while in Fig. 116 the sky gives the light-dark alternation, being light in the green-light picture.

Film Inspection. A Kinemacolor film should be inspected thoroughly by the careful operator, who is jealous of his results and of his reputation, before projecting it for an audience. Every splice should be looked at, first, to see that it is not out of frame in the ordinary manner by a fraction of a picture, and, second, to see that it is not out of frame for color by the connection of two light images or two dark images, instead of having a light and a dark image meet at the splice. Also, note where the title joins the picture which follows it, and study it to determine whether the second image, or second image-length of film, after the last title image, is a green-light image as it should be. Also look carefully for any broken sprocket holes or weak places in the film which might break during the run, bearing in mind that the Kinemacolor film gets a harder bumping and jerking than any simple black-and-white film, and that a weak place is likely to break in the run. Any of these troubles found should be corrected. Then every projection of the film should be watched for indications of a weakening film. The film is being subjected to harder service, and a more rigorous care, if possible, is necessary than with black-and-white working at only 50 feet per minute.

Oiling. The high-speed parts of the Kinemacolor projector should be oiled only with a good grade of sewing machine oil, and they should be oiled for every reel of film, that is, for continuous Kinemacolor projection, the rapidly moving parts of the motion head should be oiled every eight minutes. The high speed requires a thin oil, and a thin oil works out of the journals quickly and requires renewal.

For the journals which have the less rapid motion, a medium heavy machine oil may be used, such as is used for ordinary projection machines, oiling up at the beginning of the afternoon and again at the beginning of the evening run, or more frequently if the use of the machine is practically continuous.

The upper reel or feed reel requires special attention, because as the film nears its end the speed of revolution of that reel becomes pretty high. The fixed spindle of the feed magazine, over which the feed reel slips, should be lubricated with vaseline, and care should be taken to see that the reel turns freely on the spindle when the magazine door is closed.

Arc Lamp. With one window of the color shutter taking out all the green light and passing only the red light for the red-light images, and with the other window of the color shutter taking out all the red light and passing only the green light for the green-light images, it will be seen that a total of only half the light of the arc which passes through the film and the lens ever reaches the picture screen, the other half (sometimes the green half, sometimes the red half) never getting any farther than the color shutter.

To give an equal brightness upon the picture screen, compared with black-and-white pictures, the Kinemacolor film and color shutter require a much brighter arc. The resistance of the rheostat may be reduced, or two rheostats may be connected in multiple to give the additional current, together with carbons of a slightly larger diameter, say $\frac{3}{4}$-inch.

Lamp currents of 60, 75, and even 100 amperes have been suggested. The maximum current used must always be a compromise between screen brilliancy and condenser breakage.

Direction of Film Wind. The feed reel requires the film to be wound with the emulsion side "inside" when the reel is full, that is, the film is started with the emulsion side next the core when rewinding. The take-up reel turns "counterclockwise" and winds the film up with the emulsion side "outside," the film being started upon the take-up with the celluloid side next the core. While the feed reel might run in either direction, it is designed to run clockwise when feeding.

FRIESE-GREEN PROCESS

It may be said of the Friese-Green process of motion pictures in natural colors by colorphotography direct from nature that it is being developed in England. How nearly ready for the market the Friese-Green process is, cannot be said. Several very successful public exhibitions of the color projection achieved by the process have been given.

The Friese-Green process resembles the Urban-Smith process in that it produces the innumerable variations of color in nature by recording them in a few primary colors and then recombining them upon the picture screen by persistence of vision. The Friese-Green system of projection uses two projecting lenses, projecting two images of two colors upon the picture screen at the same time, shifting each one fourteen times per second, that is, at the regular speed of shifting ordinary black-and-white picture film. The negative is made through a color shutter of three colors. The colors really are orange, green, and violet, but are called red, green, and blue.

Process of Manufacture. The process of making is by the use of a double camera, as shown in Fig. 119, the camera being composed of two motographic mechanisms built into a single case, each mechan-

Fig. 119. The Friese-Green Color-Motography Camera in Operation

ism using its own roll of sensitive film and its own intermittent shift mechanism, and having its own lens and its own color shutter. They are linked by being driven by the same crank shaft, and further by having one opaque shutter common to the two lenses. One of the lenses closes while the other opens, alternating until the picture is completed upon both reels of negative film, the alternate pictures being upon the two reels, respectively, when finished. In Fig. 119, the right hand of the operator turns the crank which drives the film mechanism, while the left hand is upon the panoram handle of the tripod head.

In addition to alternation in taking the negative images of the subject photographed, the two lenses take the image in a different color of light at each exposure. The color shutter, or color filter, changes for each exposure in each camera in the order of blue, green, red, blue, green, red, and so on, and as the two series of pictures are taken in alternation they are taken as follows:

(*1*) A green-light image with the left camera; (*2*) a blue-light image with the right camera; (*3*) a red-light image with the left camera; (*4*) a green-light image with the right camera; (*5*) a blue-light image with the left camera; (*6*) a red-light image with the right camera; (*7*) a green-light image with the left camera; and so on.

Projection of Film. In projecting, a similar color shutter of three colors is employed. A double motion head is used, with two arc lamps, two intermittent mechanisms, and two lenses, also two color shutters. The intermittent mechanisms and shutters are driven by the same crank handle, as are also the two color shutters.

A combination of simultaneous and alternative color projection is achieved by the two lenses and mechanisms of the Friese-Green projection head, as follows:

(*1*) The left lens projects a green-light image, and while the green light of the left lens is still upon the picture screen (*2*) the right lens projects a blue-light image upon it, thus giving the two colored images green and blue upon the picture screen at the same time; but the left lens now cuts off the green-light image and shifts its film and its color shutter, and (*3*) projects a red-light image upon the picture screen while the blue-light image of the right lens is still upon it, thus giving two images, blue and red, upon the picture screen at the same time; now the right lens cuts off the blue-light image and shifts its film and color shutter, and (*4*) projects a green-light image upon the screen while the red-light image of the left lens still continues, thus giving two images, red and green, upon the picture screen at the same time; again, while the green-light image from the right lens continues, the left lens shifts and (*5*) projects a blue-light image, thus giving two images, green and blue, upon the picture screen at the same time. This cycle of colors is repeated indefinitely or until the end of the scene. As the images are shifted for color, each image shows a progressive position of all of the objects in motion in the subject, so that motion as well as color is depicted.

The Friese-Green picture films when on reels of course come in pairs, and a pair of reels of 1,000 feet each will run upon the screen twenty minutes, each film running 50 feet per minute.

Splices. Splices, if made at all, require great skill and care. A break may be repaired sometimes by a patch without cutting out any of the film, but if any cut is to be made, it is necessary to cut three images from each of the two films, and in the same place, that unison between the two films of the pair may be maintained, and that synchronism between the images and the color shutters may be maintained.

Color Shutter. The color shutter of the Friese-Green camera and projecting machine is not the disk of the Urban-Smith device, but a transparent film band, endless, colored in sections with the three colors, and traveling with the film through the film gate of camera or projecting machine, respectively.

Care in threading up is necessary, with reference to the film pair, to get correspondence, and with reference to framing for color of the two color shutters or color bands.

Development of System. To show as far as possible the progress which has been made in the development of the Friese-Green system, and the time which has been consumed in the experiments, the following is quoted from an English magazine, *The Kinematograph Weekly*, of November 24, 1910:

At Pendleton's Pictures, Co-operative Hall, Crewe, on Thursday last, Mr. Friese-Green gave a display of his system of natural color animated photography.

The pictures were shown during the ordinary program, an announcement being made from the platform that a picture in color of Mr. Friese-Green's son signaling with colored flags, taken six years ago, and one as recently as two months ago, would be shown. These films, it was explained, were taken in the laboratory, and the commercial results of Mr. Friese-Green's labors would be submitted in about a month's time.

In the six-year-old picture, three colors apparently were employed and the machine ran at ordinary speed. The results were crude, the picture was unsteady and fuzzy, and occasionally such colors as there were would disappear altogether.

The two-year-old results were very much better. The subject was a revolving vase of flowers, but it was revolved so slowly as to be almost a *still* picture. There was a lack of true color in the blooms, but now and then a fine stereoscopic effect appeared.

The last, and two-months-old picture was again an improvement, and represented a colored-ware dessert dish containing fruits. The results obtained were curiously varied. Intermittently the color rendering would appear to be very good indeed, and the stereoscopic effects produced by the dish revolving would be very pronounced, giving a beautiful, soft, and natural appearance. The unsteadiness, however, was very great, and the defects, it must be confessed, were largely apparent.

It remains to be seen what Mr. Friese-Green can accomplish when he comes to do outdoor work; the films described above were the results, of course, of long exposures and slow rates of speed. Whether his methods infringe any of the master patents is a matter upon which we do not feel called upon to express an opinion. That question may be left with those directly interested. It is apparent from the above account of the results obtained that progress has been made, and we wish Mr. Friese-Green success in his continued efforts.

FILM MANUFACTURERS

The object of this list is to give to the reader some little knowledge of any manufacturer whose name or trademark he may see upon a film. The list does not pretend to be complete, not even for the manufacturers in the United States. In many instances, no information other than the home office address, or the American importer's name and address, is given. Possibly some of the manufacturers mentioned have discontinued the production of films, but so long as their films still are used in picture theaters, such data as is given concerning them will have an interest for that reason.

Adolpho Croce, Milan, Italy.

Ajax Film Company, A. J. Clapham, Managing Director, 12 East 15th Street, New York, N. Y.

"Ambrosio." Societa Anonima Ambrosio, Torino, Italy. Films imported into United States by New York Motion Picture Company, 1 Union Square, New York, N. Y., and sold through the Motion Picture Distributing & Sales Co.

Ambrosio Film Manufacturing Company, 16 Rue St. Marc, Paris, France. Films imported into United States by New York Motion Picture Company, 1 Union Square, New York, N. Y.

American Cinephone Company, 124 East 25th Street, New York, N. Y. Controlling patents for the Cinephone, a talking picture device, for the United States. Markets its product only through the American Kinograph Company.

American Film Manufacturing Company, A. M. Kennedy, General Manager, Bank Floor, Ashland Block, Chicago, Ill. Making picture film under the sign of the "Flying A." Sales through the M. P. Distributing & Sales Co.

American Kinograph Company, 124 East 25th Street, New York, N. Y., J. A. Toupin, Manager. Operating under the Cinephone patents. Supplies Cinephone sound records and picture film for the Cinephone Talking Pictures, also Cinephone talking machines for the Cinephone sound records.

American Motor Racing Picture Company, 330 East 35th Street, Chicago, Illinois. Irregular releases of special film pictures.

American Mutoscope and Biograph Company, New York, N. Y. Commonly called the "Biograph Company." Trademark, an "AB" monogram in a circle Offices and studio in New York. Office address, 11 East 14th Street, New York, N. Y. Studio also in southern California Licensed under patents controlled by the Motion Picture Patents Company of America Film leased to licensed film exchanges only.

Animated Motion Picture Patents Company, New York, N. Y. A patent-holding company controlling a patent issued to Meredith Jones for a camera making a motion picture without stopping the film behind the lens.

Animatophone Syndicate, Ltd., 11 Denman Street, Piccadilly Circus, London, W., England. Talking and Singing Pictures.

Aquila Film Manufacturing Co., Torino, Italy.

Atlas Film Company, 10 East 15th Street, New York, N. Y. Films sold through the Distributing and Sales Company. Manufacturing picture films under the trademark of Atlas supporting the globe of the earth with a picture film encircling both athlete and globe.

Barker Motion Photography, Ltd., Topical House, 1 Soho Square, London, W. Sign of the Bulldog.

Bat Films. Lyons, France, 8 Rue du President Carnot.

Bavaria Film Manufacturing Company, Strassbourg.

"Biograph" Film, the American Mutoscope & Biograph Co.

"Bison" trademark, New York Motion Picture Manufacturing Co.

W. Butcher & Sons, Ltd., Camera House, Farringdon Avenue, London E. C., England. Making picture films under the trademark, "Empire."

Capitol Film Co., Washington, D. C., Sig. G. Bernstein, General Manager. Making picture films under the name of "Capitol Films," with the sign of the capitol dome in the letter "C."

Carlton Motion Picture Laboratories, 1 Union Square, New York, N. Y. Films sold only through the M. P. Distributing & Sales Co. Making picture films under the trademark "Reliance."

Champion Film Company, Mark M. Dintenfass, General Manager, 12 East 15th Street, New York, N. Y. Making picture film under the trademark "Champ" and the sign of the victorious gladiator. Sells through the M. P. Distributing & Sales Co.

"Chicken Film," Pathé Frères, sometimes so called because of the trademark, the sign of the red rooster.

E. G. Clement, 30 Rue du Petites-Ecuries, Paris, France.

Columbia Film Company, 301 West 27th Street, New York, N. Y. Sells only through the M. P. Distributing & Sales Co.

Continental Film Manufacturing Company, Copenhagen.

Cosmopolitan Film Company, Ltd., London, England.

Cricks & Martin, London, England. Makers of film pictures under the "Lion's Head" trademark.

Defender Films, Wm. H. Swanson, General Manager, 111 East 14th Street, New York. Sold only through the M. P. Distributing & Sales Co.

Ste. Drankoff, 12 Nicolaciwich, Saint Petersburg, Russia.

Eclair Films, Paris, France, 8 Rue St. Augustin.

Edison Manufacturing Company, 65 Lakeside Avenue, Orange, New Jersey. Making picture films with the trademark of the "Circle E." Licensed by the Motion Picture Patents Company of America, which controls the Edison patents. Films are leased to licensed film exchanges only.

Essanay Film Manufacturing Company, 435 North Clark Street, Chicago, Ill. Studios in Chicago and Colorado. Licensed under the patents controlled by the Motion Picture Patents Company of America. Leases film to licensed film exchanges only. Trademark, the Indian head.

Film d'Art Film Manufacturing Company, Paris, France.

The Gaumont Company, Paris, France. Office, 57 Rue St. Roch. Usines et Theater, 12 Rue de Alouettes, Paris. American office, 125 East 23rd Street, New York. Films imported into United States by George Kleine, Chicago, Ill.

Gnome Motion Picture Company, offices and studios at southwest corner of Park and Tremont Avenues, Bronx, New York, N. Y. Licensed under patents of the Animated Picture Patents Company.

Great Northern Film Company. Home office, "Nordisk Film Company, Copenhagen." American office, 7 East 14th Street, New York, N.Y. Trademark of the Polar Bear on the Earth Globe.

Hepworth Manufacturing Company, London, England, making picture films under the trademarks of "Hepworth" and "Hepwix."

Hispano Films, Barcelona, Spain, Craywinckel, 20 San Gervasio.

David Horsley, German Savings Bank Building, 4th Avenue and 14th Street, New York, N.Y. Making picture films under the trademark of "Nestor." Sold through the M. P. Distributing & Sales Co.

"Imp" trademark, Independent Motion Picture Co.

Independent Moving Picture Company of America, 102 West 101st Street, New York, N. Y. Carl Laemmle, President. Manufacturing picture films under the trade name "IMP" and the trademark of an imp associated with a shield design bearing the letters "IMP." Films sold through the Motion Picture Distributing and Sales Company.

Itala Film Manufacturing Company, Torino, Italy. Films imported into United States by New York Motion Picture Company, 1 Union Square, New York, N. Y.

Kalem Film Manufacturing Co., New York, N. Y. Making picture films under the name "Kalem" and the sign of the blazing sun with the word "Kalem." Licensed by the Motion Picture Patents Company of America. Films leased to licensed film exchanges only.

Kinemacolor Company of America, Allentown, Pa. Making Kinemacolor picture films and manufacturing Kinemacolor projecting machine. Kinemacolor is a process of motion pictures in natural colors by color photography direct from nature.

"Kineto" Films. Kineto, Ltd., 48 Rupert Street, Shaftsbury Avenue, London, W., England.

George Kleine, 52 State Street, Chicago, Ill. Imports "Gaumont" and "Urban-Eclipse" films into America under license of the Motion Picture Patents Company of America. Films are leased to licensed exchanges only.

"Latium" Film, Manifattura Cinematografica Italiana.

"Le Lion" Cinematographes Company, 15 Rue Grange-Bateliere, Paris, France. Manufacturing films under the trademark of the lion rampant mauling a roll of film.

"LION'S HEAD" FILM, Cricks & Martin, London, England.

LUBIN MANUFACTURING COMPANY, Philadelphia, Pa. Making picture film under the trademark of the Liberty Bell. Licensed under the patents controlled by the Motion Picture Patents Company of America. Leases film to licensed film exchanges only.

LUX FILM MANUFACTURING COMPANY, Rue Louis-le-Grand, Paris, France.

MANIFATTURA CINEMATOGRAFICA ITALIA, 77 Via Appia Nouva, Rome, Italy. Making picture films under the trademark, "Latium Film."

G. MELIES, New York, N. Y. Making picture films under the trademark of the "Star." Licensed by the Motion Picture Patents Company of America. Films leased to licensed film exchanges only.

MOTION PICTURE DISTRIBUTING AND SALES COMPANY, 111 East 14th Street, New York, N. Y. Act as selling agents for a number of American and Foreign manufacturers. Handle Éclair, Imp, Yankee, Bison, Powers, Thanhouser, Ambrosio, Atlas, Champion, Nestor, Itala, Defender, Lux, Cines, Solax, Great Northern, Columbia, Capitol and Reliance films for the United States.

MOTION PICTURE PATENTS COMPANY OF AMERICA, 10 Fifth Avenue, New York, N. Y. A company organized to control the Edison, Biograph, Armat, and Vitagraph patents pertaining to the motion picture industry. Some of these patents are the following: Reissue 12,192; 578,185; 580,749; 586,953; 588,916; 673,329; 673,992; 707,934; 722,382; 744,251; 770,937; 771,280; 785,205 and 785,237. The following companies are licensed by the M. P. Patents Company to manufacture picture film under the above listed patents: The *American Mutoscope and Biograph Company* of New York City; the *Edison Manufacturing Company* of Orange, New Jersey; the *Essanay Company* of Chicago; the *Kalem Company* of New York City; *Lubin Manufacturing Company* of Philadelphia; *Pathé Frères* of Bound Brook, New Jersey; the *Selig Polyscope Company* of Chicago; the *Vitagraph Company of America* of New York City; and *G. Melies* of New York City. In addition, *Pathé Frères* are licensed to import from their factories in France, and *George Kleine* of Chicago is licensed to import "Gaumont" and "Urban-Eclipse" films. This makes a total of ten licensees of the Motion Picture Patents Company. The output of each of the licensees is limited by the terms of its license. All films manufactured or imported under the licenses of the Motion Picture Patents Company are not sold, but remain the property of the manufacturer or importer, being leased to licensed film exchanges only for a term of months, during which time the licensed film exchange rents the films to exhibitors, and at the end of which time the exchange returns the film to the manufacturer or importer to be destroyed. By this means, only the latest films may be obtained from the licensed film exchanges. The object is to cause the withdrawal from theater exhibition of films which have had a reasonable amount of wear, and to maintain as high a standard as possible in the film theaters both for lateness of titles and freedom from wear of the films.

NATIONAL FILM MANUFACTURING & LEASING CO., 12 East Fifteenth Street, New York City. A manufacturing and leasing company operating independently of the Motion Picture Patents Company of America, and independently of the Motion Picture Distributing and Sales Company.

NAVONE FILM, Torino, Italy.

"NESTOR" FILMS, made by David Horsley, German Savings Bank Building, 4th Avenue and 14th Street, New York, N. Y.

NEW YORK MOTION PICTURE COMPANY. Offices and Studio in New York City. Office address, Lincoln Building, 1 Union Square, New York, N. Y. Making picture film under the trademark of "Bison" and the sign of a buffalo rampant. Sells film only through the M. P. Distributing & Sales Co. Importing agents for the United States for "Ambrosio" and "Itala" films.

PARAGON BIOSCOPE COMPANY, Ltd., 13 Cecil Court, Charing Cross Road, London, W. C.

PATHÉ FRÈRES. Trademark of the Red Rooster. Home office, 14 Rue Favart, Paris, France. American offices in New York, Chicago and San Francisco. Two studios in France and an American studio and factory at Bound Brook, New Jersey. Produce American and foreign subjects, importing many foreign subjects into America. Leaders in so-called "hand colored" pictures, colored by stains in an imitation of the colors of nature, the colors being applied to the film by machinery. American factory and American importations of foreign films licensed under patents controlled by the Motion Picture Patents Company of America. Films leased to licensed film exchanges only.

THE POWERS COMPANY, 241st Street and Richardson Avenue, New York, N. Y. Making picture films under the trademark of "Powers Picture Plays." Sales through the M. P. Distributing & Sales Co. This company takes its name from "Pat Powers," and should not be confused with the Nicholas Power Company, which makes the Cameragraph projecting machines and does not make film.

"RELIANCE" trademark, CARLTON MOTION PICTURE LABORATORIES.

REVIER MOTION PICTURE COMPANY, H. Revier, President, Majestic Theater Building, Salt Lake City, Utah. The trademark is a picture of a temple with the word "Revier."

SELIG POLYSCOPE COMPANY, Chicago, Illinois. Offices at Dearborn and Randolph Streets. Studio and factory at North Western Avenue and Irving Park Boulevard. Making picture film under the sign of the "Diamond S." Licensed by the Motion Picture Patents Company of America. Leases film to licensed film exchanges only.

SICANIA FILM FACTORY, 45 Piazzi Giuseppe Verdi, Palermo, Italy. The trademark "Sicania."

SOCIETE CINES. Making films with the trademark of the Wolf-and-Babes. Office address, 11 Rue Saint Augustin, Paris, France. Studios in France and in Italy.

SOLAX COMPANY, 147 Fourth Avenue, New York, N. Y., factory and studio at Flushing, Long Island. Making picture film under the name "Solax." Sold only through the M. P. Distributing & Sales Co.

SUNNY SOUTH FILM COMPANY, Rhodes Building, Atlanta, Ga.

THANHOUSER COMPANY, manufacturing with the trademark "TCO." Offices and studio at New Rochelle, N. Y. Films sold through the Distributing and Sales Company.

Tyler Film Company, Ltd., London, England, makers of film pictures under the trademark, "T. F. C."

Unitas Film Manufacturing Company, Torino, Italy.

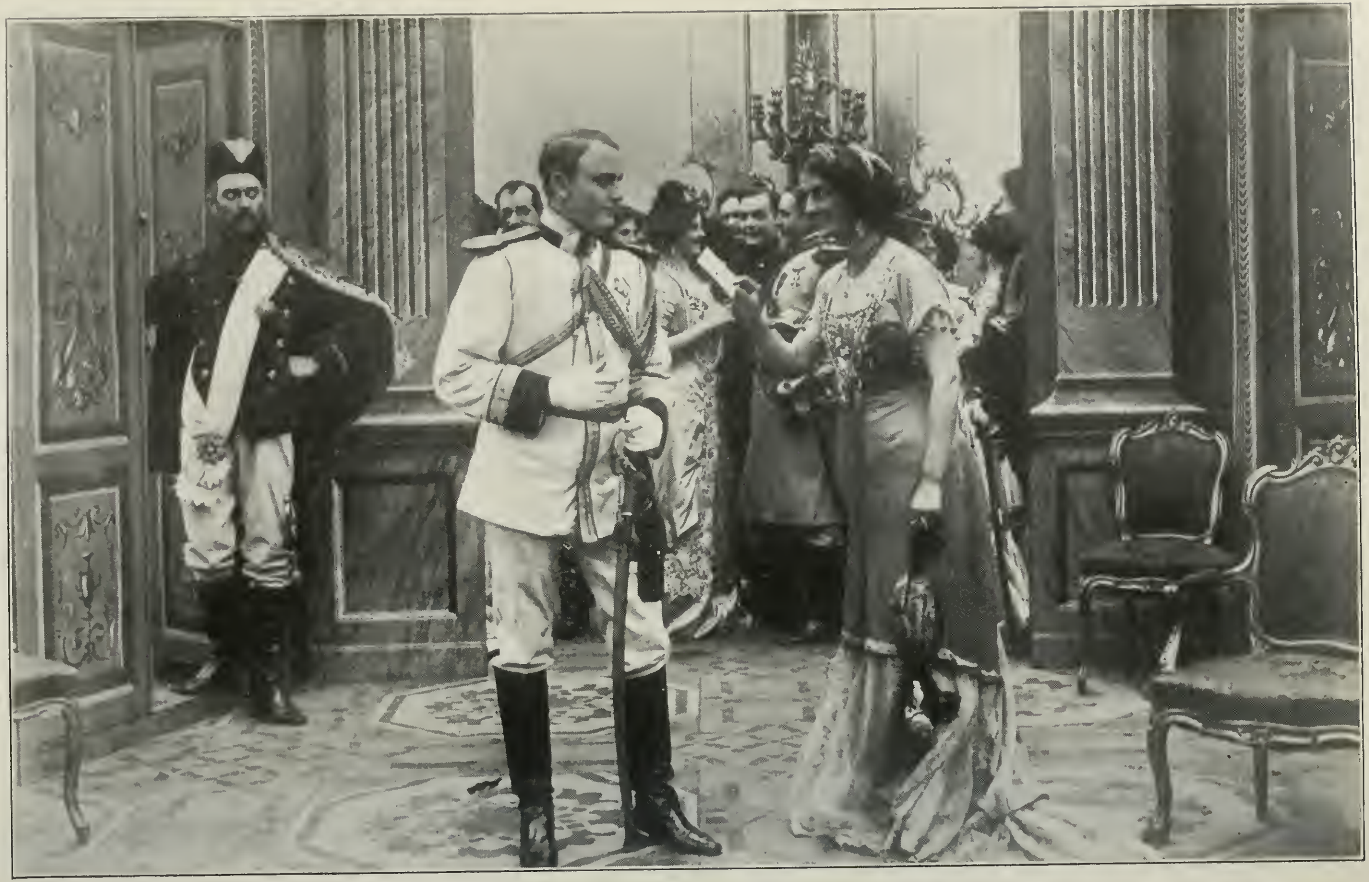
Charles Urban Trading Company, film publishers, Urbanora House, 89 Wardour Street, London, W., England. "Urban" and "Urban-Eclipse" black-and-white films and "Urban-Smith" Kinemacolor films.

The Vitagraph Company of America, 116 Nassau Street, New York, N. Y. Studio on Long Island. Licensed under the patents controlled by the Motion Picture Patents Company of America. Film leased to licensed film exchanges only. Trademark, the letter "V" surmounted by an eagle with spreading wings.

Warwick Trading Company, Ltd., 113 Charing Cross Road, London, W. C., England.

"Wrench" Films, 50 Gray's Inn Road, London, W. C., England.

Yankee Film Company, 344 East 32nd Street, New York, N. Y. Making picture film under the trade name of "Uncle Sam Films" and the sign of Uncle Sam in costume holding a white "Y." Films sold through the M. P. Distributing & Sales Co.



THE DUKE'S JEALOUSY IS AROUSED
Scene from Photoplay, "The Cossack Duke"
Courtesy of *Great Northern Film Company, New York*

PHOTOGRAPHY

THEORY

The making of photographs may be divided into three very general or theoretical steps: *First*, producing an image of the scene or object of which it is desired to make a photograph. *Second*, reco.ding the image in permanent form. *Third*, copying, multiplying, or reproducing the image into as many finished photographs as may be desired.

Any of these steps may be accomplished in any of several ways by the photographer, according to the results which he desires to attain, or according to the limitations of the apparatus which he has available. Thus, images usually are formed for photography by means of a lens; but if the photographer has no lens, or arbitrarily decides not to use it, he may form an image without it. The image formed being composed of rays of light of different strengths, the second step taken by placing in the image a surface bearing a substance which is sensitive to light and which will be discolored to different degrees by the different strengths of the different rays and by the spots of light formed by them in the image. This second step produces the record of the image, and from it a number of finished photographs may be produced in a manner not altogether unlike the production of several thousand newspapers by a printing press after the typesetters have made ready the printing types and the engravers have made ready the printing picture plates.

MECHANICAL DETAILS

Camera. The camera is a dark box within which the photographer forms the image. The light is admitted to the camera during the making of the photograph, and in most cameras during the preparation for the photograph and the proper adjustment of the camera for forming the desired image.

Pin-hole Image. To understand just how the image is formed in the camera, perform the following experiment:

Take a paper box, white inside, about the size of a shoe box. Remove half of the lid. In the middle of one end of the box, punch a hole with a darning needle, making a hole about $\frac{1}{16}$ inch in diameter, with smooth edges. Place the box in the window, the hole toward the street, and with the half-lid on that part of the top of the box near the street. Draw the shade to the top of the box, and obscure the remainder of the window as well as other windows of the room so that the only light received will be through the small hole in the end of the box—the *pin-hole* as it is termed in photography, Fig. 1. On the inside of the box, at the end opposite the pin-hole, there will

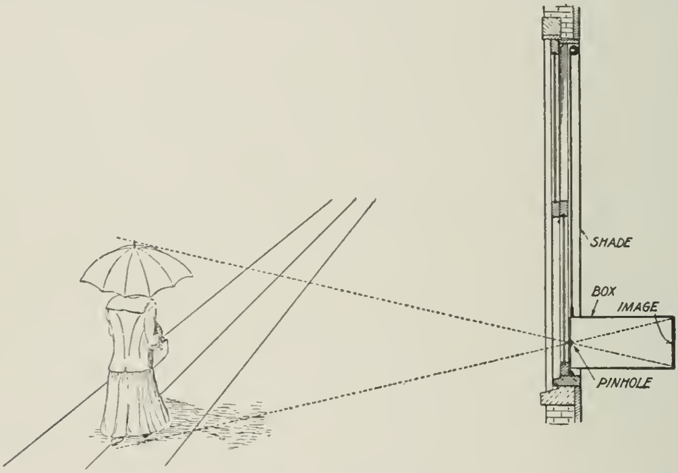


Fig. 1. Pin-hole Image

be formed an image of the objects upon the opposite side of the street. The image may be viewed through the open half of the top of the box, and will be seen a living image, in natural colors, but inverted, its size depending upon the length of the box. Try it with boxes of different lengths, or moving a white card in the box.

Inverted Image. The reason why the image is inverted is shown in Fig. 2, in which the object, the pin-hole, and the image are represented. All rays of light pass in straight lines, and all the light from the top of the tree at the right which gets through the pin-hole passes in a straight line to the bottom of the image at the left; light from the bottom of the tree goes to the top of the image. This is true for every point of the view; hence, the view is inverted in the image.

Now with a lead pencil, enlarge the pin-hole until the pencil can pass through. Note the difference in the image. It is blurred. Each point in the scene makes a spot in the image as large as the hole in the box; yet the image as a whole is brighter. A spectacle lens placed over the hole in the box might make the image sharp, but at this point the pin-hole experiment may be abandoned and the working of the photographer's camera as it is commercially used may be taken up to complete the study of the first step in theory, or the formation of the image in practice.

Buying a Camera. The learner who intends either to make moving pictures after learning still photography, or to make *good* still photographs, must first purchase a tripod camera. Concerning the work of hand cameras, a photographer handling amateur work at a holiday resort is quoted as saying that of more than a

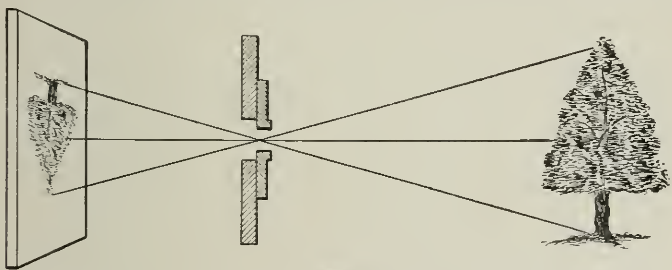


Fig. 2. Inverted Image

thousand negatives developed by him in one summer there were not twenty good pictures and hardly forty good negatives. Only with the tripod camera can the photographer know what he is doing and then operate his camera intelligently and successfully.

The camera purchased for intelligent work must be either 4-inch by 5-inch size, with bellows draw of 12 inches or more, or 5-inch by 7-inch size, with bellows draw of 15 inches or more. Smaller than 4 by 5 is too small for intelligent work by the ambitious amateur, and larger than 5 by 7 is too heavy for amateur work. In either case, the camera should have a single swing, and must have a rising front and holders for glass plates; it may have a convertible rectilinear lens or a more expensive convertible anastigmatic lens, but in either case the lens must be convertible and should be equipped with an iris diaphragm and an automatic shutter. The usefulness of each of these features will appear as the operation of the camera is described. A camera 4 by 5 may be had at a catalogue price of $25.00 or more, and a camera 5 by 7 at $33.00 or more, filling all requirements. Two extra plate-holders should be bought, that six plates may be carried into the field. A tripod and focusing cloth complete the necessary field equipment, with the possible addition of an exposure meter.

Construction of Camera. The body of the camera consists of the back frame, the front frame, and a base. The base connects the back and front frames and upon it the front frame moves as upon a track. Connecting the back and the front is the bellows. The front carries the lens, mounted upon a detachable lens board; the back carries the ground glass or focusing screen, and permits the insertion of one of the plate-holders in such a manner that when the plate-holder is inserted the ground glass is pushed out of its normal position and the glass plate within the holder occupies the position formerly held by the ground glass.

Place the camera in the window as the shoe box was, and open shutter and diaphragm. The shutter is opened by setting its index to "T," or "Time," and operating it with the rubber bulb. The diaphragm is opened by setting its index to the lowest number, probably 8. Extend the bellows until a sharp image is seen upon the ground glass. Look *at* the ground glass, not *through* it. If the back of the camera and the operator's head are covered with the focusing cloth, it will not be necessary to darken the room for this experiment. By moving the camera front to different positions, it will be observed that the image is sharp in only one position. This is the position of focus of the lens.

Lenses. The lens is composed of a barrel carrying the shutter and iris diaphragm in its middle portion and carrying at each end a "lens cell," or metal mount, into which the glasses of the lens are fixed. The glasses may be removed from the lens barrel by unscrewing their mounts from the barrel. Unscrew the front lens cell and extend the bellows until the image upon the ground glass is sharp again. This is the focus for the "back combination," or that cell which still remains in the lens. The bellows is longer, the image is larger. Sometimes the front combination of the lens is of still longer focus than the back combination, giving an image still larger, but with still longer extension of the bellows.

Replace the lens cells. Select in the image a distant object, such as a chimney 500 feet away. Focus sharply upon it by moving

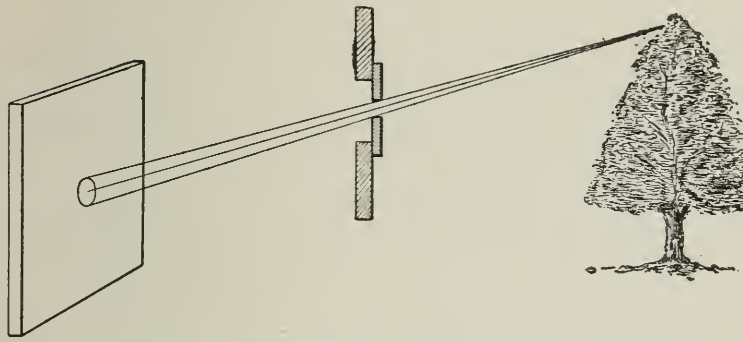


Fig. 3. Pin-hole without Lens

the camera front until the chimney is sharp. Note a near object, a house or tree within 50 feet; it is not sharp. To focus sharply upon the near object, it is necessary to extend the bellows slightly. Now the distant object is not sharp. Try to place the focus between the two; then reduce the iris diaphragm to 32 or even 64. Now both distant and near objects are sharp.

Remove both lens cells. Shut the iris diaphragm as close as it will move. Look upon the ground glass; the image of the shoe box is there. Move the bellows to different lengths; the size of the

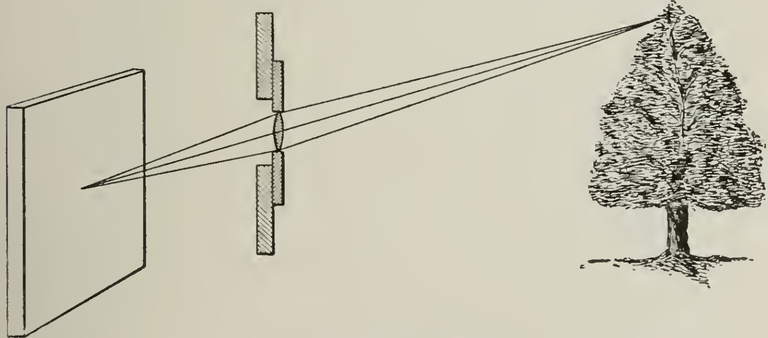


Fig. 4. Pin-hole with Lens

pin-hole image is changed but it is in as good focus in one place as another. The pin-hole image has no definite length, and everything, near and far, is in focus. Replace the lens cells. With the diaphragm still at its smallest size, the lens makes the image sharper, but a position may be found at which everything seems to be in focus, both near and far objects. This is called the *condition of universal focus.*

Focal Length. The distance from the ground glass to the center of the lens when the image is in focus upon the glass, is called the focal length of the lens, and usually is expressed in inches. The focal length of the two combinations or cells of the lens when used together is shorter than the focal length of either of them. With a 5 by 7 lens, the complete lens should have a focal length of 7 inches or a little more; each of the combinations alone should be about 12 inches, or one of them about 11 and the other about 14 inches.

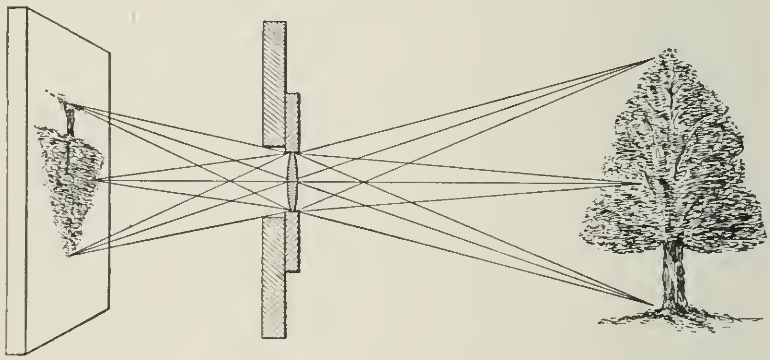


Fig. 5. Lens Image

Figs. 3 and 4 show the action of the lens. The glass of the lens bends the rays of light, which proceed from a point in the subject until they reach the lens and then are bent by the lens to approach until again they meet in a point, making a sharper spot of light on the ground glass in Fig. 4 with the lens than in Fig. 3 where the pin-hole without the lens is shown. This is true of all points of the subject, as shown in Fig. 5.

The distance from the lens to the place where the ray again comes to a point depends upon the strength of the lens in bending the rays, and this distance is the focal length of the lens. In Fig. 6 the back lens cell alone bends the light to bring it to a focus; while in Fig. 7 both front and back lens cells bend the light, one after the other, bending it to a much greater extent, bringing it to a focus in a shorter distance, giving a shorter focus or shorter lens length, and producing of course a smaller image on the ground glass.

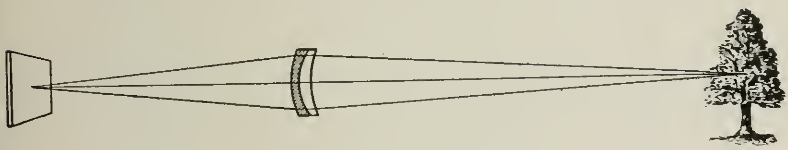


Fig. 6. Long-Focus Lens

Measuring Length. Without a camera, a lens may be measured approximately by focusing the image of the sun upon any convenient surface, such as a small card, then measuring with a ruler the distance from the middle of the lens barrel to the card. With a camera, focus upon a very distant object, and measure from the middle of the lens barrel to the ground glass. A more accurate method, where a camera of sufficiently long bellows is available, is to focus upon any close object until the image on the ground glass is exactly the size of the object. Measure the distance between the object and the ground glass and divide by four. To make this measurement conveniently, cut two slips of paper of equal length and attach one to the ground glass and the other to the glass of the window. Place the camera on a table where it may slide toward the window to change the size of the image. Use the largest diaphragm opening. When the edges of the image of the slip of paper are sharp and when the image on the ground glass and the slip of paper on the ground glass are of the same length, the distance between the object and the image will be four times the focal length of the lens.

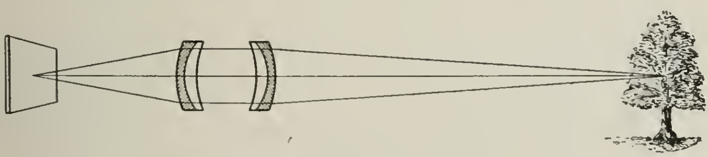


Fig. 7. Short-Focus Lens

Position of Diaphragm Opening. The influence upon the image of the diaphragm opening, or "stop," and of its position with reference to the lens is shown in Figs. 8, 9, and 10. In each of these figures, there are shown a photographic subject composed of straight lines, a lens, a stop opening, and an image of the subject formed by the lens through the diaphragm. In each figure, the subject and the image are shown in a front view, while the lens and diaphragm

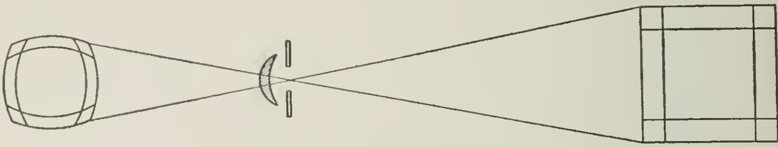


Fig. 8. Barrel Distortion

are shown in side view, or rather in sectional view as though cut through the middle.

In Fig. 8, the diaphragm opening is in front of the lens, between the lens and the subject to be photographed. The result is a bending of all the straight lines of the image, drawing the ends of the lines toward the middle line of the image, both horizontally and vertically. This form of distortion is called *barrel distortion.* In Fig. 9, the diaphragm opening is behind the lens, between the lens and the image. This results in bending the lines of the image in the opposite direction, and produces what is called a *pin-cushion distortion.* In Fig. 10, a double lens is shown, the glasses of the lens being divided into two cells with the diaphragm or stop between them. With such an arrangement the pin-cushion distortion of the front lens cell is just balanced by the barrel distortion of the back lens cell, and the resulting image has all its lines straight. Such a lens is called a *rectilinear lens.* To avoid distortion, the diaphragm

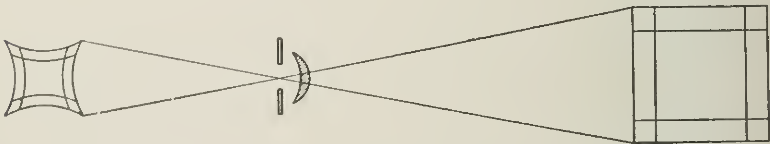


Fig. 9. Pin-cushion Distortion

must be placed between the two cells at the proper distance from both. Of the two forms of distortion shown in Figs. 8 and 9, the barrel distortion is the less objectionable, and when a single lens is used, it should be placed in the back end of the lens tube, even though it be the front cell of the complete lens. The single lens serves satisfactorily for landscape and portrait work, in either of which it may be said there are no straight lines In photographing

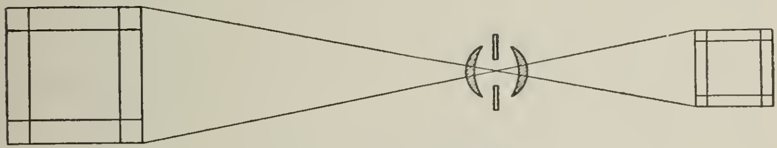


Fig. 10. Rectilinear Lens

architectural subjects, where the straight lines of the sides of buildings are near the edge of the plate, and in interiors, only the rectilinear lens may be used if passable results are desired.

Focusing. Bringing the desired image into focus is controlled by the position of the ground glass at the proper distance from the lens, and also by the size of the opening in the diaphragm or stop. Every point in the image is formed by a mass of light rays which is conical in form, as big as the stop opening at the lens, and tapering down to a point at or near the ground glass. When the exact tip of this cone is upon the surface of the ground glass, the point is in focus and sharp in the image. When the tip of the cone is a little behind or in front of the ground glass, the point is slightly blurred, but if not too much blurred it may be said to be still in focus. The amount of blur depends upon the size of the cone at the place where the ground glass is met. Fig. 11 shows a lens with

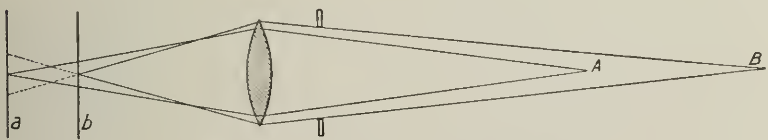


Fig. 11. Lens without Diaphragm Stop

a large stop opening. The point *B* of the subject is in focus at the point *b* of the image; the point *A* of the subject is in focus at the point *a* of the image. With the ground glass at the vertical line, through *a* the point *A* will be sharp and the point *B* will be blurred in the image. With the ground glass at the vertical line, through *b* the point *B* will be sharp in the image and the point *A* will be blurred.

Fig. 12 shows the same system with a smaller stop opening. The cone from the point *A* is smaller where it crosses the vertical line through *b*, hence the blur will be less, and the focus more nearly

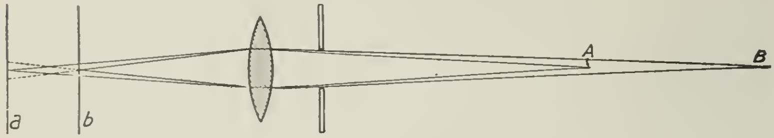


Fig. 12. Lens with Diaphragm Stop

correct. With the ground glass midway between the points *a* and *b*, both will be slightly blurred, but the blur will be less with the smaller stop opening, Fig 12 "Depth of field" in an image refers to the distance from the nearest object in focus to the farthest object in focus. With the smaller stop opening, the depth of field is increased.

Spherical Aberration. Lenses ground by machines present spherical surfaces upon both sides, although not of concentric spheres. Such a lens bends a ray of light to a greater degree when the ray passes through the lens near the edge than when the ray passes through the lens near the center. This is illustrated in Fig. 13. By the greater bending, the rays from the object *C* which pass near the edge of the lens are brought to focus on the line *c*, while those through the central portion are brought to focus upon the line *c′*. This defect in the lens is reduced by the use of a lens which is meniscus in form, having one convex and one concave surface, as illustrated in Fig. 14. It is reduced also by the use of a smaller stop opening, as illustrated in Fig. 15.

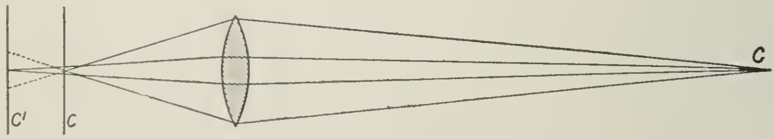


Fig. 13. Spherical Aberration in Convex Lens

Chromatic Aberration. The light rays of different colors are affected to different degrees by the refractive attribute of the glass of the lens. The violet light is bent through a greater angle than the yellow light, and the remaining colors, as well as the ultra-violet rays, are changed in direction through different angles. This produces the effect of bringing the different colors to focus at different distances from the photographic lens of the simplest type, viz, of a single meniscus piece of glass. The principle involved is the same

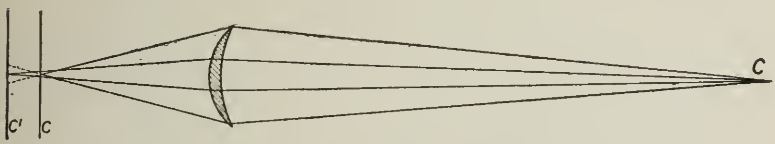


Fig. 14. Spherical Aberration in Meniscus Lens

as that by which a single ray of white light is separated by a prism into its elementary colors, a band of colored rays being secured by the separation of the single white ray.

The effect in a photographic lens is shown in Fig. 16. The ray of white light from the point *D* of the subject is brought to focus in several different points according to the colors into which the light is separated. The yellow light is brought to focus at the line *d*, while the violet light is brought to focus on the line *d′*. Of all the colors composing white light, yellow affects the eye to the greatest degree and, consequently, in focusing the camera by looking at the image upon the ground glass, the yellow light is appreciated by the eye and the ground glass is brought to that position in which the yellow rays are in focus. At the same time, the red and blue rays are so nearly in focus that they unite to give the appearance of white light in focus upon the screen. When the sensitive plate is placed in the camera, occupying the position of the ground glass, and the light is permitted to fall upon it through the lens,

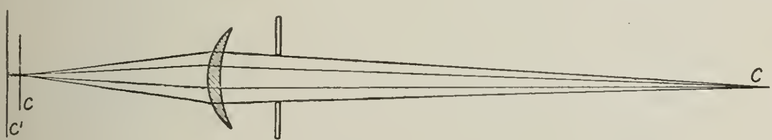


Fig. 15. Spherical Aberration Reduced by Diaphragm Stop

the conditions of appreciation of the light are changed. The sensitive plate is most sensitive to the blue—the violet and the ultra-violet rays—and these are not in focus upon its surface.

Outside of the lens, the remedies for color aberration are to focus through a blue glass, to use a blue ground glass, or to wear blue spectacles. Another method is to know the specific correction for the lens used and to move the ground glass the proper distance toward the lens after focusing upon the yellow image.

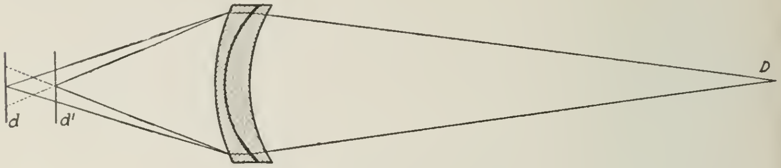


Fig. 16. Chromatic Aberration

Within the lens, the correction may be made by uniting two pieces of glass of different refractive powers, one lens being ground "positive," or thicker in the middle than in the edges, and the other one being ground "negative," or thinner in the middle than in the edges. Two of the surfaces have the same curvature and the two lenses when completed are cemented together, Fig. 17. Even the cheapest classes of lenses are thus made double, except in the smallest sizes and when of short focus. A rectilinear lens, composed of two single lenses, each of which is corrected for chromatic aberration, would present a combination of glasses such as is shown in section in Fig. 18 or Fig. 19.

Astigmatism. The meaning of this word is *with no point.* Its meaning as applied to a photographic lens is that the lens has not the ability to bring to a focus at a point all of the rays proceeding from a point in the subject. Thus a point in the subject becomes something else in the image. The bundle of rays passing from a point in the subject and through the stop opening takes the form

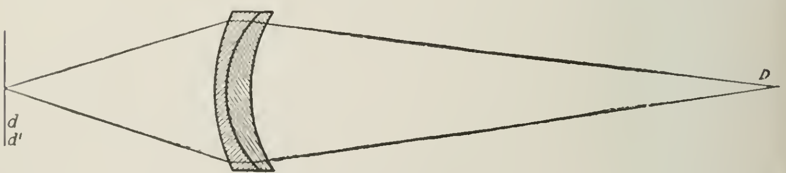


Fig. 17. Achromatic Lens

shown in Fig. 20. The best focus is obtained by placing the ground glass at the line *b*, where the point takes the form of a cross. When the ground glass is at the line *a* nearer the lens, the point takes the form of a short radial line, or ellipse, with its longer axis radial from the center of the image; when the ground glass is at the line *c* farther from the lens, the point takes the form of a short arc about the center

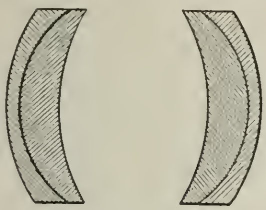


Fig. 18.

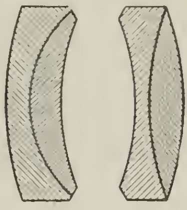


Fig. 19.

Achromatic Rectilinear Lenses

of the image, or of an approximate ellipse of which the shorter axis is radial and the longer axis is an arc instead of a straight line.

The remedy for astigmatism lies in the construction of the lens, and lenses which are corrected for astigmatism are called

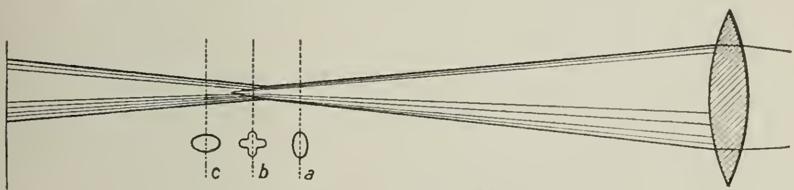


Fig. 20. Bundle of Rays with Astigmatism

anastigmats. Two, three, four, and even five pieces of glass are used sometimes in producing single lenses free from astigmatism, chromatism, and spherical aberration. Fig. 21 shows a single lens

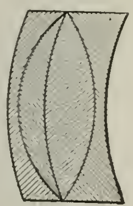


Fig. 21.

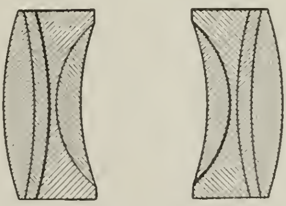


Fig. 22.

Anastigmatic Lens Combinations

of four glasses. Fig. 22 shows the glasses of a aouble, or rectilinear, lens of two single lenses having eight glasses in all.

The art of the lens maker is a delicate one. A lens should be bought and used by the photographer, and not tampered with.

A good lens should be kept in a dust-proof case when not in use. It may be brushed with a soft camel's-hair brush and wiped with soft clean tissue paper to remove dust—not a cotton or silk rag, which may carry grains of grit to scratch the surface of the glass.

Shutters. When the camera is prepared for exposing a plate to an image, the lens stands as a window in the front of the camera. The purpose of the shutter is to close the lens window until the moment for exposure, then to open the lens and again to close it after sufficient amount of light has passed through to impress the image upon the sensitive plate.

Cap. The simplest of shutters is the cap, which is a shallow box fitting closely over the front of the lens barrel. For exposures of several seconds or more in duration, the cap offers the most convenient means, while for exposures of less than one-half second, the cap can hardly be removed and replaced quickly enough, and some sort of automatic opening and closing device should be used.

Leaf. The leaf shutter consists of hinged leaves which meet and overlap to close the lens opening. They are forced open by a spring and forced closed by a spring. An exposure of as brief a space as $\frac{1}{100}$ second is feasible with the leaf shutter; and some shutters are advertised to make even shorter exposures. By the addition of an air piston, the closing of the shutter may be delayed until after the piston has completed a predetermined travel, thus giving an exposure longer than the shortest of which the shutter is capable. The usual "automatic" leaf shutter may be "set" before exposure to give an exposure of from one second to $\frac{1}{100}$ second. The shutter may be adjusted also to hold the lens open until released. Exposures longer than one second may be made by the "time" adjustment, opening the shutter at the beginning of exposure and closing it after the proper lapse of time, as in the case of exposure with the cap. The leaf shutters usually work between the lenses, near the diaphragm.

Curtain. The curtain shutter consists of two curtains on spring rollers inside the camera just behind the lens. When the shutter is adjusted for exposure, one of the curtains is in front of the lens; the other is above, rolled up. Upon release of the shutter, the lower curtain rolls down, opening the lens; after the desired lapse of time, the upper curtain unrolls and passes down, stopping over the lens and closing it.

Focal Plane. The focal plane of the camera is the position of the image formed by the lens. When ready for an exposure, the sensitive plate is located in the focal plane. The focal-plane shutter, which is a curtain just in front of the plate, is so called because it is placed as near to the plate as possible and, therefore, near the focal plane of the camera. The curtain has a slit which may be adjusted in width or it has several slits of different widths. When released the curtain rolls without stopping, and the length of time during which the light is permitted to shine upon the plate is determined by the speed of the curtain and by the width of the slot. With a shutter of this type, exposures as short as $\frac{1}{1500}$ second may be given. The shutter is available equally for longer automatic exposures and for time exposures.

Testing. An automatic shutter has a scale for setting the speed of the shutter, usually marked 1, 2, 5, 25, 100, meaning, respectively, 1 second, $\frac{1}{2}$ second, $\frac{1}{5}$ second, $\frac{1}{25}$ second, and $\frac{1}{100}$ second. The exposure given to the plate is not always true, however, to the value indicated by the scale of the shutter. The method of test is:

Photograph with the automatic shutter at one of its settings an object moving at a known speed; then calculate the length of time of the exposure from a measurement of the amount of movement visible in the photograph. The distance moved in the photograph is to the distance moved by the object during the exposure as the focal length of the lens is to the distance of the lens from the object. When the distance moved by the object and the speed of the object is known, the time required to move through that distance may be known, and that is the actual exposure of the shutter for the speed setting under which the test was made.

A wheel driven at a constant and known speed may carry a mirror on its face near its edge, the mirror reflecting the light of the sun or of an arc lamp into the lens. In this case, the distance and focal length need not be measured; the angle of the arc which the revolving mirror makes upon the plate while the shutter is open will give the duration of the exposure for the shutter setting under which the test was made.

Under test, a new fabulously high-priced leaf shutter showed an accuracy of only 60 per cent. Another cheap leaf shutter gave exactly the same length of exposure for its $\frac{1}{25}$ marking and for its

$\frac{1}{100}$ marking, the exposure being $\frac{1}{35}$ second for either of them. A fair shutter test easily made is as follows:

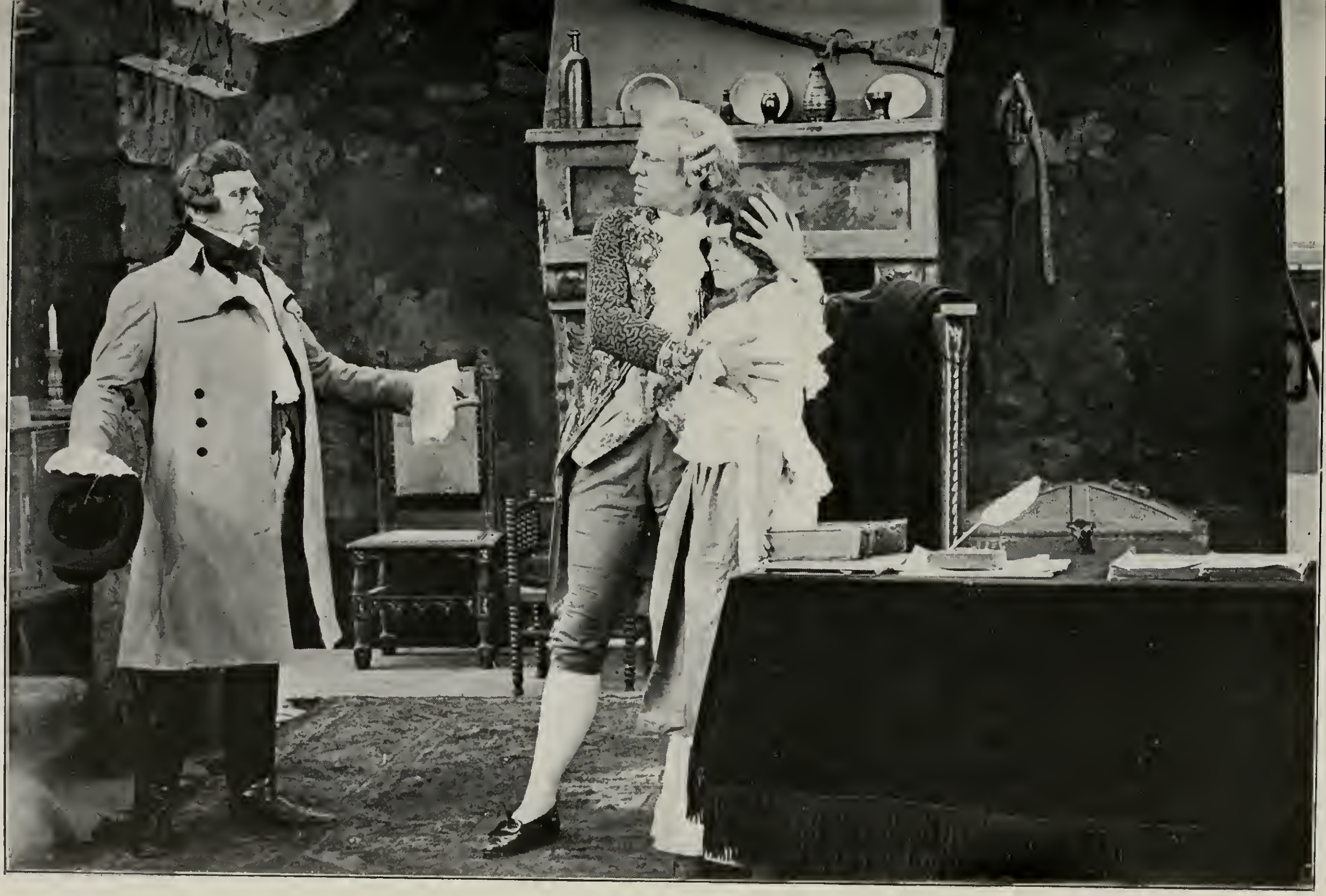
With stop f/11 and shutter speed $\frac{1}{25}$ expose a plate, and with stop f/64 and cap, time, or bulb exposure, give 1 and $1\frac{1}{4}$ seconds as accurately as possible. These exposures are nearly equal, and when developed in the same tray or tank the plates should be alike.

The speed markings of a new shutter may be accepted as correct; the medium speeds $\frac{1}{5}$ and $\frac{1}{25}$, which are used most by the amateur, are likely to be nearly accurate. The shorter exposures are likely to be too long; the longer ones are likely to be too short. An old or second-hand shutter should be tested for speed before good work is attempted with it.

Plate-Holder. For experimental work for the purpose of gaining a knowledge of photography sufficient for the making of motion pictures or good still pictures, glass dry plates should be used. Cut films or roll films may be adopted later, but the more reliable glass dry plate should be used by the beginner.

The plate-holder has two draw slides, and when each is drawn there is revealed a set of clamps for holding a glass plate inside the holder. The handle, or edge, of each slide is white on one side and black on the other. In the dark room, by dim ruby light, place a glass plate in each side, with the film, or dull, side facing out, and replace the slides, white side out. The plate-holders should be numbered on each side, the first holder being *1* on one side and *2* on the other; the second holder being *3* on one side and *4* on the other, etc. When exposing plates, always expose first the No. *1* side of the first holder, or the No. *1* plate, then the No. *2* plate, then No. *3*, etc. Upon returning to the dark room for development, the subjects upon each plate will be remembered by remembering the order of the exposures, and it is likely that only one exposure will have been made upon each plate. Without some system for exposing plates in order, it is possible that upon development one plate will show a ship sailing through a forest, and another plate will show nothing but the fog of an imperfect ruby lamp.

The camera is so arranged that the ground glass may be removed and the plate in its holder substituted. The removal of the ground glass may be by actually taking away the frame which holds it, but the more common method in small cameras is to force the plate-



SCENE FROM "THE TREASURE OF THE FOREST," BY GAUMONT
This is a Hand-Colored Film, the Plot of Which is Laid in the Days of the French Revolution.
Courtesy of the *Kleine Optical Co., Chicago*

holder into the camera in front of the ground-glass frame, the ground-glass frame being held by springs which yield to permit the plate-holder to enter. When the plate-holder is removed subsequently, the ground-glass frame automatically resumes its proper position for focusing.

Darkroom. The darkroom is a room which is not merely dusky, but a room which has absolutely no white light. It may have red light until it is far from dark, hence "darkroom" is but a name. It must not have any light which will affect the sensitive plate. No daylight. Windows, doors, and transoms must be examined for cracks. After remaining in a darkroom for a few minutes, cracks will be seen which were not noticed at first. A bathroom at night makes a desirable darkroom for photographic operations. A movable platform across the tub offers a work table, and running water is convenient. A ruby lamp must be purchased. If a satisfactory screen is made for the window, such a dark room may be used during the day. No white light must get to the plate except through the lens during the interval of exposure. A little practice enables the photographer to load his plate-holders by touch alone, no light being needed. This enables plate-holders to be loaded in daytime in any closet by a little care in closing the cracks around the door.

A convenient darkroom may be built of rough boards in any corner of any room, basement, attic, or barn, the cracks being carefully closed by papering inside and outside. A developing shelf should be the height of the waist. If running water is desired in the darkroom, a sink should be convenient to the developing shelf, but running water in any but a very large darkroom is an objection rather than an advantage. In the wall back of the developing shelf a window should be cut into which a sash is fitted carrying a ruby glass. Outside of the darkroom, on a shelf or bracket, should be the lamp for furnishing the ruby light, so placed as to shine through the window. Shelves for chemicals, apparatus, and supplies are outside the darkroom. The darkroom contains nothing but a developing shelf, a door, and a window provided with removable colored glass. Dishwashing, and other processes not necessarily darkroom processes, may be done elsewhere.

Routine of Camera Operation. Select the view. Open lens. Open stop. Focus and manipulate the camera until you have upon the ground glass the image you want, no more, no less. Decide upon the stop opening to be used and the length of exposure to be given. Set stop opening. Close lens. Adjust shutter to selected speed setting. Insert plate-holder. Draw dark slide of plate-holder. Release automatic shutter or otherwise make the exposure. Replace dark slide in plate-holder, black out. Remove plate-holder from camera.

Practice this routine without plates in the holders, or without drawing the dark slide from the plate-holder, until entirely familiar with all of the steps. Many plates are spoiled by drawing the dark slide before closing the lens, or by failure to draw the dark slide at all.

PRODUCING THE IMAGE

The picture is made upon the ground glass of the camera. If the photographer has the patience and skill, or the good luck as an amateur, to secure such an arrangement of his subject upon the ground glass as makes a good picture there, then the mechanical and chemical processes which follow will merely record that picture and will produce a pleasing photograph unless the record should be spoiled by accident. The view selected to be photographed often is forced upon the photographer. He must produce a picture of this house, or that bridge, or of the children of the family. The motion-picture camera man must photograph the set stage or such other subject as the producer in charge may direct. Yet the control of the image in nearly every instance is so completely in the hands of the camera operator that the resulting picture is better or worse as he is careful or careless, and according as he understands the possibilities of his camera to control the arrangement of the details of his subject. All of this control of the resulting picture, after the voluntary or enforced selection of the principal subject, must be exercised before the exposure of the sensitive plate or film is made by the operation of the lens shutter. After the lens has been opened upon the subject, transmitting the light of the image to the sensitive plate, no further change can be made in the picture.

The making of the picture, that is, the making upon the ground glass the image which is to be recorded to become the finished photograph, may be divided into seven points for consideration and study, as follows:

(1) The selection of the principal object to be photographed.

(2) The selection of a background or setting for the principal object.

(3) The lighting or direction of light falling upon the subject as a whole.

(4) The size of the principal object in the image.

(5) The composition and balancing of principal and subordinate objects in the image.

(6) The prominence of the background.

(7) The avoidance of disagreeable distortions in the image.

Principal Object. The total task of photographing usually is the making of a photograph which may be used to record some one object, such as a house, a tree, a flower, a person, or an animal. Sometimes it is merely "a pretty scene," but in this case the photographer should decide upon some object of the scene to form the principal object of the picture. He should give such prominence to some object that the resulting photograph will be in substance a picture of that principal object, yet will embody in its background or scenic setting the "pretty scene" which it was desired to photograph. Right at the beginning, and in the most fundamental of all of the principles of picture making, the camera operator has the power to control the image, to make or spoil the picture, even though commanded by an outside influence as to his general subject. Whether he is inspired by the beauty of a scene to make a photograph of it, or whether he is commanded by a companion or by an employer to make a photograph of it, he still has the power to make some object a principal object, to hold other objects subordinate to it, and to mold the whole into an arrangement in the image on his ground glass which will result in a photograph worthy the name of a picture when finished. Each picture must have a principal object or it is at best only a photographic memorandum.

Background. In portrait work in a studio, the backgrounds are painted as desired, and brought in or carried out, and turned and placed as needed. And for scenic work it is almost the same. Suppose that it is commanded that a photograph be made of a rosebush in blossom in the front yard of a house. If the house would form a desirable background, set up the camera at the front fence. If the front fence would form a desirable background, photograph the rosebush from the house. If either side fence is better, place the camera at the opposite side of the yard. If none of the surroundings are pleasing as background objects, there is still the possibility of viewing the bush from above so that the grass of the lawn, and not any fence, house, or other object is included as a background. This view may be had from the top of a stepladder, from an upper window of the house, or even from the height of the tripod above a porch floor. With some of these background arrangements surely the resulting picture will be better than with others. Get the best one, just to show that you are master of the camera, even though some one else dictates what your principal object shall be.

When photographing persons or animals, the "principal object" usually may be brought to a suitable background. When photographing a house, the inclusion in the image upon the ground glass of a little more of the foreground, or of a little of one of the houses standing at one side of the "principal object," or of a tree standing near, partakes of the fundamental principle of the selection of a background and gives the camera operator some power to make his image nearer to a picture and farther from the memorandum type of photograph.

Lighting. With immovable objects, such as trees, houses, and rosebushes, illuminated by the sun, the photographer has two methods of controlling his lighting, both of which consist merely in taking advantage of natural conditions by the selection of the proper time for making the exposure. The sunlight falls upon the object at different angles and in different directions at different hours of the day. Whether the object is photographed in the early morning, in the late morning, at noon, or in the afternoon is usually within the control of the photographer, and it makes a difference in the pictorial value of the photograph. Few landscapes are pretty at noon, with the shadow exactly under each tree and bush; they are far better between two o'clock and five o'clock in the afternoon. The horizontal rays of sunlight become objectionable again in the late afternoon. The second method of control for immovable objects is the selection of an overcast or hazy day in preference to a day of direct sunlight. Usually the direct sunlight, with sharp shadows is preferable, but here again the operator has control of the image in his hands.

Size of Object. The size of the principal object is controlled by the distance from the camera to the object and by the focal length of the lens. The nearer the camera is carried to the object to be photographed, the larger will be the image of that object upon the ground glass. The longer the focal length of the lens used, the larger will be the image upon the ground glass. The image of the main object, therefore, may be enlarged by using one of the lenses alone instead of both of them double.

Composition and Balance. By the terms composition and balance reference is made to the many relations which exist among the masses of light and shade among the lines of the image. The rules are so numerous that all of them cannot be followed at all times, and many of them apply only to specific instances of subject arrangement. A few of the more general rules may be kept in mind when arranging the image upon the ground glass.

A profile portrait shows on one side the light face against the darker portion of the background, and on the other side the dark hair against the lighter portion of the background. Each side of the picture has its lights and its shadows. A landscape, even the picture of a building, should bear the same analysis. A balanced picture should have a principal shadow, and some minor shadows. It should have a principal high light and some minor high lights. With the principal shadow and the minor high lights on one side of the image and the principal high light and minor shadows on the other side, it is likely that an approximate balance will be obtained. For example: a heavy mass of foliage is at the lower right, as a near bush or tree; a few scattered masses are at the middle left and upper left, as distant bushes or trees; a roadway or stream runs from lower left to upper right, showing a large light spot at lower left and smaller light spots at upper right; the large light is a little higher or a little lower than the large shadow, not dead level that a line connecting them would be parallel to the margin. That sounds like a coldly critical analysis suitable for producing a stiff and formal picture, yet a scene sought out in nature and photographed from a viewpoint carefully selected to secure this arrangement of lights and shadows will rank above a hand-camera snapshot and will repay the amateur's effort.

In a water scene, a ship at anchor may be photographed from the pier with another pier in the background. Place the dark hull of the ship near the lower edge of the picture and at the right of the middle line; place the distant pier above the center on the left of the picture. The masts of the ship cut up into the upper right corner and break up the sea and sky into minor high lights. The major high light is the unbroken sea at the left of the ship, lower left corner of the picture.

Strictly parallel lines are objectionable in a picture unless they are parts of an object and unavoidable, as the masts of a ship. Any line parallel to the margin of the plate is objectionable except the side lines of buildings, which are unavoidable. An imaginary line joining two high lights or two shadows should not be parallel to an edge of the plate, nor should an imaginary line from the principal shadow mass to the principal high light be parallel to any edge of the plate if it can be avoided. The horizon line requires care in this detail.

Horizon Line. The placing of the horizon line has much influence in the composition and balance of the picture. Care must be taken that the horizon line does not cross the principal object at an undesirable point, nor should the apparent horizon divide the picture exactly in the middle. Where a hillside is included in the landscape, it may be made to give an inclined or irregular line for the horizon. Where a level horizon is unavoidable, it should be broken if possible by the objects of the picture.

Point of View. The point of view is the location of the camera whence the image is made. Changing the point of view is the most powerful means which the camera operator has for arranging and controlling his image. The selection of the background depends almost solely upon the point of view chosen. The size of the principal object is largely controlled by the choice of the point of view, while the composition and balance are almost wholly controlled by the selection of the point of view, together with the selection of the lens length.

Prominence of Background. As a rule, the image may be separated into principal object and background, even though the background or setting of the principal object be really the more important portion of the picture, and the portion primarily desired. The relative size of the principal object and its associated background objects may be controlled by the lens length. With the double lens, focus upon a view containing a near tree as a principal object. Note the size of the distant trees. Remove the front lens cell, move the camera back to twice the distance from the principal tree, and focus again. By the change of the lens and the change of the point of view, the principal tree will be the same size as before; note that the distant trees are much larger than before, thus giving greater prominence to the objects of the background. Also, by the use of the longer focus of the single lens, less of the horizon is included in the image, and less of the surrounding landscape is shown as a background to the principal tree, that which is included in the image being shown in larger size. If the front and back cells of the lens

Fig. 23. Perspective Distortion

are different in length, the front cell alone will give still more prominence to the background objects, a greater extension of bellows and a still more distant viewpoint being required to keep the principal object at the original chosen size. When it is impossible to secure a point of view near enough to the principal object to secure a large image, the longest lens will give the largest possible image.

In the case of a portrait, the background is entirely unimportant in detail, and is most satisfactory when shown merely as a blurred surface of light and shade. This is effected by opening the diaphragm to its largest stop size, then bringing the face of the portrait to a sharp ocus. The background will be blurred because it is "out of focus." Out-of-door portraiture profits by the same rule, and the rule applies generally where the picture is to be a photograph of a specific object and the background is not a part of the object. Where both foreground and background are required to be sharp, a small stop opening must be used to secure the result.

Distortions. Usually, any distortion of the image caused by the lens is objectionable. Blurring the background in portraiture and similar pictures by using the shallow field incidental to the large stop opening is in itself a form of distortion which is made to serve a useful purpose and is an aid to the operator in the control of his image.

Barrel distortion and pin-cushion distortion, which have already been discussed, should be avoided as far as possible, particularly in architectural subjects.

Perspective distortion will be observed if the camera does not stand level upon its tripod. In landscape views, such distortion

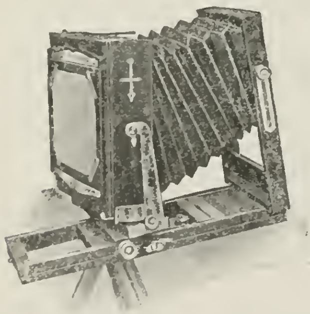


Fig. 24. Camera with Swing Back in Use

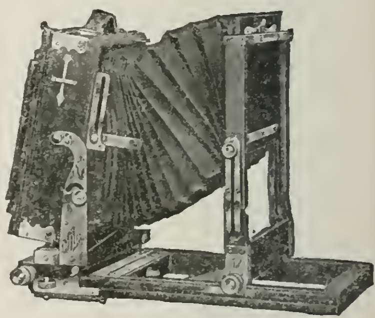


Fig. 25. Camera with Rising Front in Use

usually is negligible. In architecture it is ludicrous, Fig. 23. The remedy is to keep the ground glass vertical, or nearly so. This is done by the swing back and by the rising front.

Swing Back. When the back of the camera, carrying the ground glass and the plate-holder, is pivoted or hinged, the body of the camera may be tilted to bring the desired scene upon the ground glass, and the swinging back of the camera then may be adjusted to bring the ground glass vertical or nearly so, Fig. 24. By this adjustment, the perspective distortion will be corrected, but the focus is more difficult and a smaller stop opening will be required to give a sharp focus over the entire plate.

Rising Front. With the camera placed about level, more of the sky or more of the foreground may be included upon the plate by raising or lowering the lens in the front of the camera, Fig. 25. This avoids perspective distortion, but the amount of adjustment thus obtainable is somewhat limited.

RECORDING THE IMAGE

The recording of the image consists of two processes—exposing the sensitive plate and developing the exposed plate into a negative.

Dry Plates. The art of the chemist is brought into use in recording the image of the lens. The known substance most sensitive to light is finely divided nitrate of silver suspended in gelatine. The manufacture of this substance is not attempted by the photographer. A thin skin of the prepared gelatine is spread upon glass plates and dried. The plates thus made are sold under the name of photographic dry plates. These are bought by the photographer in light-proof sealed packages and loaded into plate-holders in the darkroom.

Films. Flexible transparent celluloid films coated with the prepared gelatine are used instead of the glass, if desired, and may be had for pictures up to a 5 by 7 size, either in packets of cut films or in rolls of proper width on which exposures may be made one after another. In motion-picture work, the celluloid film is a necessity and it is used universally in commercial motography.

Exposure. When the plate-holder is inserted in the camera, the lens closed, and the dark slide withdrawn, the lens is opened just long enough to permit a sufficient amount of light to pass through the lens to affect the sensitive silver of the dry plate—neither too much, nor too little. This process of administering to the plate the proper dose of light in the form of the image is called *exposing the plate.*

The greatest problem in photographing any subject is the best arrangement of the image upon the ground glass, and the next greatest is the determination of how long a time, in seconds or fractions of a second, to permit the light to flow through the lens to impress the image properly upon the sensitive plate.

The amount of light from a given subject which falls upon the sensitive plate to impress the image depends upon the size of the stop opening and the length of time during which the lens is left open for the exposure. Light flowing through the stop opening is just like water flowing through a hole. If you increase the size of the hole, the bucket will be filled with water in less time, and in direct proportion to the change of the size of the hole. *Double-size hole, half the time to fill the bucket. Half-size hole, double time to fill the bucket. A hole ten times the size will fill the bucket in one-tenth the time.* This rule holds strictly true in the case of the photographic exposure. Increase the size of the stop opening and the light passes through faster, giving the plate sufficient light in a shorter time.

A larger plate requires a greater quantity of light because there is more surface to be worked upon. The light spreads from the lens, and the farther back from the lens the light must go to reach the plate, the more it spreads out and the weaker it becomes. *The lens length has a direct influence in the strength of light upon a plate from a given subject through a given opening* or, to state the same rule differently, *the lens length has a direct influence in determining the size of stop opening which must be used to effect the same strength of light upon a plate from a given subject.*

Stop Numbers. A plan of numbering stops according to the size of the opening has been devised which removes the actual focal length of the lens from the calculation of the strength of the light upon the plate, by including the focal length of the lens in the determination of the stop number. There are in common use in America two systems of stop numbers—the *focal-factor* system and a modification called the *uniform system.* The plan used in the focal factor system consists of numbering the stops in fractions, as 1/8, 1/16, 1/32 of the focal length of the lens; these are written *f*/8, *f*/16, *f*/32, etc., or *F*/8, *F*/16, *F*/32, etc., or *f*-8, *f*-16, *f*-32, etc., or *f*:8, *f*:16, *f*:32, etc.

The stop number *f*/16 means that the diameter of the stop opening is 1/16 the focal length of the lens. An *f*/16 stop for a 4-inch lens is 1/4 inch in diameter. An *f*/16 stop for an 8-inch lens is 1/2 inch in diameter, giving four times the area of the stop opening, giving four times the quantity of light, but since the light goes twice as far before it reaches the ground glass or sensitive plate it will spread over four times the area and, therefore, will be of the same strength, or intensity, on the plate with the 1/2-inch stop *f*/16 of the 8-inch lens as with the 1/4-inch stop *f*/16 of the 4-inch lens. This is of great convenience in writing of exposure timing, because by the use of the focal-factor system of stops all the rules given for exposure will be true for cameras of all sizes and for lenses of all lengths of focus.

In both systems each stop number requires either double or half the exposure of the next stop number, the stops being alike at *f*/16 and No. 16. If the stop numbers on a scale are 4, 8, 16, 32, 64, 128, 256, it is "U. S." or uniform system. If the stop numbers on a scale are 8, 11, 16, 22, 32, 45, 64, it is focal-factor system. In either case, as the numbers increase each number requires double the time of exposure required for the preceding or next smaller number. In any lens, the largest opening possible may not be an even stop number, and this first marking of the scale may vary from the "double time" rule. Thus, if a lens will work with an opening of *f*/7, its scale will be marked 7, 8, 11, 16, etc., if for the focal-factor system; or 3, 4, 8, 16, etc., if for the "U. S." system. In Table I the numbers in the two systems are compared.

TABLE I

Equivalent Stop Numbers in Focal-Factor and Uniform Systems

f/2	f/3.5	f/4	f/4.5	f/5	f/5.6	f/6.3	f/7
No. 1/4	No. 3/4	No. 1	No. 1 1/4	No. 1 1/2	No. 2	No. 2 1/2	No. 3
*f/8	*f/11	*f/16	*f/22	*f/32	*f/45	f/64	f/90
No. 4	No. 8	No. 16	No. 32	No. 64	No. 128	No. 256	No. 512

*The stop numbers in the two systems which are most commonly met and used.

Plate Speed. Some plates are coated with a gelatine film which is more sensitive to light than others. As a standard, plates such as Seeds 26x, Stanley, Hammer Fast, Cramer Instantaneous Iso, and Standard Extra may be taken as most suitable in speed for amateur work. These plates list 130 on the Watkins scale of plate speeds. A faster class of plates comprises Cramer Crown, Hammer Extra Fast, Seed 27, and Kodak and Premo Films. These list at 180 on the Watkins scale and require only three-quarters the exposure to impress the image as fully as upon a plate of the 130 class.

Light Intensity. In filling a bucket with water running through an opening, the pressure which is behind the water will influence the rate of flow and will influence the time required to fill the bucket. The intensity of the light which illuminates the subject and the nature of the subject itself are the two elements which influence the rate of flow of light through the lens opening. On a dark day the light does not pour through the small stop opening as fast as on a day of blinding sunlight. Even in the same bright sunlight, the quantity of light sent to the camera from a dark green tree is less than the quantity sent from the white sails of a ship. One consideration of the nature of the subject also is its distance from the camera.

If the average amateur photographer were asked the exposure for a summer landscape, he would probably say, carelessly, *f*/16 and 1/25 of a second. That is the hand-camera way and gives but twenty good negatives out of a thousand exposures.

The intensity of light depends upon the height of the sun above the horizon, which varies with every day of the year and with every hour of the day. With a clear sky and an average subject, Table II gives in seconds the proper exposure (Watkins 130 list plate) for *f*/16 stop for each hour of the year, by months, for the latitude of the northern portion of the United States.

In the southern portion of the United States, three-quarters of this exposure is sufficient; and on the equator, probably one-half is sufficient, and the May-June-July column may be used all the year around, with the 5 A. M. and 7 P. M. figures omitted.

For a hazy day—good daylight but cloudy enough to obscure the sun—give double the exposure as a correction for the clouds. On a heavily overcast, gloomy day, give four times the exposure as a correction for clouds.

Nature of Subject. The nature of the subject to be photographed has an influence even greater than the time of day or condition of the clouds. For pictures in the middle of the day, a glance at the table shows that the midwinter exposure with sun is but little more than double the midsummer exposure with sun. The exposure for cloudy days is only twice or four times that for sunny days. But the correction for the nature of the subject even with outdoor subjects may be two hundred times as much for one subject as for another.

The following corrections may be applied to Table II to com-

TABLE II

Day and Hour Exposure Chart

A. M. P. M.	Jan.	Feb.	Mar.	Apr.	May June July	Aug.	Sep.	Oct.	Nov.	Dec.
5 A.M.					1					
6 A.M.			1	1/2	1/5	1/2	1			
7 A.M.	2	1/2	1/5	1/10	1/10	1/10	1/5	1/2	2	2
8 A.M.	1/2	1/5	1/10	1/10	1/10	1/10	1/10	1/5	1/2	1/2
9 A.M.	1/5	1/10	1/10	1/15	1/15	1/15	1/10	1/10	1/5	1/5
10 A.M. to 2 P.M.	1/10	1/15	1/15	1/25	1/25	1/25	1/15	1/15	1/10	1/10
3 P.M.	1/5	1/10	1/10	1/15	1/25	1/25	1/15	1/10	1/5	1/5
4 P.M.	1/2	1/5	1/10	1/10	1/15	1/15	1/10	1/5	1/2	1/2
5 P.M.	2	1/2	1/5	1/10	1/10	1/10	1/5	1/2	2	2
6 P.M.			1	1/2	1/5	1/2	1			
7 P.M.					1					

pensate for the difference in the character of the subject of different images.

1/20 exposure for sky and clouds, where the foreground objects do not form a part of the picture.

1/10 exposure for sea and sky, ships at a distance at sea, views at a distance across the water.

1/4 exposure for open views, where the important portion of the view is in the distance and the foreground is unimportant.

1/2 exposure for very light objects of importance in the foreground.

Exposure time given in the table is suitable when the important objects of the image are 20 to 100 feet from the camera and are neither white nor black, neither very light nor very dark.

Twice the exposure time given in the table for objects nearer than 20 feet, or for dark objects of importance in the foreground of the image.

Four times the exposure time for portraits in shade of heavy foliage, and for dark objects nearer than 20 feet.

Sixteen times the exposure time for pictures in dense woods where side light as well as top light is obstructed by the foliage of the trees.

Near sunset, five times the exposure in order to compensate for the yellow color of the sunset light.

Interiors, if very well lighted by windows and with light walls, 100 times the table values.

Interiors, if not well lighted, 500 to 5,000 times.

When the sun is in front of the camera so that the shady side of the subject is being photographed, the exposure should be doubled.

Calculation of Exposure by Table. To calculate an exposure requires that the proper $f/16$ time for average plate and subject be taken from Table II. If the subject is an average one and the summer day is bright, then there is no correction to be applied, the stop is set to $f/16$, and the figure taken from the table is set upon the automatic shutter and the exposure is made. A few exceptions may be studied.

The summer hotel presents from across the valley a view which the visitor wishes to take with him. At one point in the road a group of trees between the road and the hotel obscures the hotel, but by taking a viewpoint farther along the hotel is free from the obstruction and the group of trees at one side of the middle of the image balances the hotel at the other side. The trees being nearer and larger are the "main object" of the composition, but the building is the more important. It is painted white. Trees behind it show its outline definitely, and both the trees behind and the "main object" group of nearer trees break the horizon line. The horizon line is placed high—three-fifths from the bottom and two-fifths from the top line of the picture. If possible, the camera is so positioned by its selection of viewpoint that some small object breaks the foreground on the side opposite the "main object" group of trees. The exposure is: Summer, 2 P. M., by Table II, 1/25 second; important portion of the view is in the distance and foreground unimportant, correction 1/4; the exposure should be 1/100 second at $f/16$, but better 1/25 second at $f/32$ to increase the sharpness of the distant object. *In a light subject, give less rather than more time than given in the table.*

Fig. 26. Watkins Exposure Meter

Further along, the visitor passes through a wood and notes a clump of pretty ferns. The table says 1/25 second; correction for deep wood, 16; correction for dark color (green) of ferns, and near the camera, to have the image of the ferns large, 4. Time 64/25 or

$2\frac{1}{2}$ seconds at $f/16$. *In a dark subject, give too much rather than too little time by the table.*

Exposure Meters. The exposure meter is a device for measuring the strength of the light which falls upon the subject. It takes the place of Table II and of the correction for the clouds. Two types of exposure meters in general use are the Watkins, Fig. 26, and the Wynne, Fig. 27.

The principle of both meters is the same. A disk of paper which is discolored rapidly by light is movable behind a slot, and beside the slot are bits of color which the paper matches in the course of its discoloration under the influence of light. The more intense the light, the more rapidly does the exposed bit of the paper disk become discolored, and the sooner does it reach a tint which matches one of the bits of color adjacent to the slot. The time required to match the darker color is taken as actinic value of the light. An exposure-calculating disk forms a part of each meter. Upon and near the calculating disk are sets of figures for (*a*) the actinic or meter value of the light, as noted in the number of seconds which is taken by the paper to discolor to match the dark standard tint; (*b*) the speed of the plate which is to be used in the exposure; (*c*) the diaphragm stop; and (*d*) the required exposure in seconds or fraction of a second.

Fig. 27. Wynne Exposure Meter

The difference between the two meters is found in the calculating device. In the Watkins, the stop number is set opposite the plate number; then opposite the time required for the paper to darken is found the time required to impress the image upon the plate, that is, the exposure time, to which the correction for the nature of the subject must be applied. This appears to be the more convenient meter for the amateur either with hand camera or tripod. In the Wynne, the time required by the paper to darken is set opposite the speed number of the plate; then opposite the stop number is read the required exposure for a standard subject, to which the correction for the nature of the subject must be applied. This is the more convenient for the motion-picture camera operator because of an exposure limitation in the motion-picture art. The Wynne meter is preferred by many fixed camera operators who have become familiar with it. Full instructions for use accompany either meter when purchased.

There are also upon the market many exposure meters, so-called, which are but calculating devices for combining the date table with the cloud correction, subject correction, stop number, and plate speed. Perhaps, when facility has been acquired with one of them, it would be found convenient.

Exposures with Single Lens. When the front lens of a double lens is removed, for the purpose of obtaining a larger image, or to increase the prominence of the background, the focal length of the lens has been changed, without changing the markings of the diaphragm scale; these markings, therefore, are not correct for the single lens. To obviate this, some lenses have two or three sets of markings on the diaphragm scale, one for the double lens and one for a single lens if both singles be of the same focal length, while if the singles be of different focal lengths there may be three markings, one for the double lens and one for each of the singles.

Where the singles are of the same focal length, the exposure time for a single lens will be four times that for the double lens with the same stop setting, to compensate for the difference in focal length between double and single.

Where the singles are of different focal lengths, the exposure for the short single will be three times that for the double lens, and the exposure for the longer single will be six times that for the double lens.

Duplicate Exposures. When much is in doubt, and upon subjects which cannot be photographed again, two exposures may be made, using two plates, and giving different lengths of exposure. If the range of exposure is such that one plate has ten times the exposure of the other both may give good negatives, whereas, if this ratio is increased to twenty-to-one, disappointment may be met by finding one plate under-exposed and the other over-exposed. As an over-exposure is a better printing proposition than an under exposure, a good rule for duplicate exposures is as follows:

SCENE FROM PHOTOPLAY, "IN OLD CALIFORNIA WHEN THE GRINGOES CAME"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

PAYING HOMAGE TO THE QUEEN AT THE COURT RECEPTION
Scene from Photoplay, "The Son of the Executioner"
Courtesy of *Great Northern Film Company, New York*

Estimate the exposure, then give one plate half the estimate and the other plate five times the estimate.

Development. The subject having been selected and arraned upon the ground glass, and the sensitive plate having been inserted and exposed by setting the diaphragm as determined by judgment of the image, and setting and releasing the shutter as determined by meter or Table II and judgment of the nature of the subject, the field work for that particular plate is finished. Other plates may be exposed before developing the first, and development may be done either immediately after exposure or after a lapse of a few days or weeks.

The exposed plate is still sensitive to light and must be kept in the holder with the slide closed until removed in the darkroom. As the plate itself bears no evidence whatever of having been exposed, it is impossible to tell an exposed plate from an unexposed one except by applying a developer, which brings out the image if exposed and spoils the plate if unexposed. The indication in the field or in the darkroom that a plate has been exposed is the slide of the holder, which should have its white side out for an unexposed plate and its black side out for an exposed plate. The plate when exposed is said to contain a latent image, because the invisible image may be brought out and made visible by a process called *development.* This is done by soaking the plate in a chemical solution which turns the nitrate of silver black only where it has been struck by the light but does not affect it otherwise.

Negative Image. The gelatine film of the plate when developed shows the image which was seen upon the ground glass, but with its lights and shadows reversed. A black sky is seen above a white grassy foreground; a black brook flows under white trees; the figures in the picture are black of face and have white hair.

Developers. There are many different developers on the market, each with its claims. The selection is a matter of personal opinion, and in the writer's opinion there is no developer as good as pyro and soda, although it stains the fingers if the operator is careless about slopping around in the darkroom. Hydroquinone and metol developer is second choice, and this does not stain the fingers.

For the first few plates to be developed, the amateur should buy a ready-mixed developer, either liquid or powder form, to avoid the possibility of losing all of the first batch of plates through an error in compounding the developing solutions, and to avoid placing a blame upon improper exposure when the actual fault is an error in compounding the developer. Formulas for developers will be given after the processes of development with ready-mixed developers have been studied.

Trays and Covers. The developing tray is a flat dish having a flat bottom so the glass plate will lie close upon the bottom of the tray. Half a dozen should be available, each the proper size for one plates. Covers for the trays should be light tight. A good cover is a developing tray of such size that, when turned over the smaller developing tray, it will come down to the developing table or shelf all around the edge. Almost as good but not so convenient a cover is a folded paper larger than a tray laid across the top of the tray and a flat weight, such as a small piece of wood larger than the developing tray,which is laid upon the paper and holds it close to the top of the tray all around the edge. A measuring glass and a thermometer will be needed.

Ruby Lamp. A "safe" light is one which may shine upon a sensitive plate without spoiling the plate. Such a light is a theoretical proposition. | To determine whether your ruby lamp is safe, cover half a plate and expose for five minutes to the direct rays of the lamp two feet away. Then develop. If the half exposed to the light is fogged, the lamp is not entirely safe, although it may be good enough. Very few lights are safe which are strong enough to be of any use. It is quite possible to use an unsafe lamp without spoiling plates; that is the object of the tray covers. The writer has developed many plates and films when he did not have a red lamp at all.

Sight Development. In preparation for development, set a tray 18 inches or 2 feet from the red lamp. Beside it place the measuring glass or a drinking glass containing four ounces—for 4 by 5—or six ounces—for 5 by 7—of developer at 65 degrees by the thermometer, ready to pour upon the plate to be developed. Have a cover for the developing tray handy. A foot or more away, beyond the reach of splashes, place the plate-holder containing the exposed plate to be developed. A pan of water, larger than the plate, is convenient for rinsing the plate, and *outside of the darkroom* but near it is a developing tray containing half an inch in depth of a fixing solution made of four ounces of hyposulphite of soda dissolved in a pint of water. All of this in full white light, that no mistakes may occur. A clock or watch in the darkroom should be so placed that it may be read by the red light. Close the darkroom door and shut off all light but the red. When the eyes have become accustomed to the weak red light, open the plate-holder, lift the exposed plate by the edges, place it in the developing tray *film side up*, glance at the clock, pour on all of the developer, making half an inch deep over the plate and wait. If the plate is a landscape, soon one part of it will begin to look gray; this is the sky coming up under the action of the developer. This should be seen in from half a minute to one minute after the developer is poured on. Soon the outlines of objects in the foreground will be seen, and by the end of two minutes the picture will be completely visible. This is not half enough development. The picture will begin to fade away, to sink into the film, and the whole plate will get dark on the surface. When the picture has had five or six minutes and seems completely spoiled, lift the plate by the edges and see whether the heavier and darker spots have come through upon the back of the plate. If the picture is visible upon the back, through the glass of the plate, it is likely that the negative is very good. Rinse in the pan of clean water for fifteen seconds or more, that the developer may be washed out of the film as well as washed off the surface, then open the darkroom door and place the developed plate in the tray of hypo outside; wash the hands free from hypo before going back into the darkroom. At this time, the negative will show the black image upon a milky film. When held to the light, the plate is opaque and the image blurred. After five minutes in the fixing bath the "milk" of the film should be fading rapidly, and ultimately there will be left only clear glass, easily seen through, with the image sharp and black. This is *sight development*. The plate is watched all the time, and when the image is strong enough, usually judged by its being visible through the back of the plate, the plate is taken from the developer, rinsed, and placed in the hypo fixing bath. For this method of development, strong, medium, and weak developers are used. Plates which seem slow in coming up are put in strong developer, while plates which come too fast are placed in weak developer. Few people understand sight development, and it requires an experienced eye to decide when the development should be stopped. It is not a good method for an amateur, but it should be used for the first plate, that the amateur may see what the process of development really is, even though the first plate be spoiled in learning.

Factorial Development. This system is a modification of the sight development system which brings development within the range of the amateur. The developer should be mixed according to a standard formula, it should be at 65 degrees by the thermometer, and the factor should be known. With ready-mixed developers, the factor usually is printed on the wrapper of the package.

A plate properly exposed will show gray in the sky in one-half minute and be fully developed in six minutes. A plate which has had a little too much exposure will be fully developed in five minutes, but it will show its first gray in twenty-five seconds from the time the developer is poured on. A much over-exposed plate will be fully developed perhaps in three minutes, but it will show its first gray in fifteen seconds. An under-exposed plate may need twelve minutes of development, because with the less exposure the image builds up more slowly and also appears at first more slowly, taking one minute to show its first gray. It has been noted that the total time of development required is always—with pyro developer—about twelve times the time required for the plate to show its first gray, hence, we have this factorial development system with this rule:

Have the developer at 65 degrees, and notice the time from pouring it upon the plate until the first gray is shown. Cover up the tray and wait until it has devoloped twelve times that long; then wash it and place it in the fixing bath. This method protects the plate from the red light except for the first minute, and even this may be reduced by holding the tray cover between the tray and the light and only removing the cover for a second every five or ten seconds until the first gray is noticed. This is a thoroughly practical system for amateurs. Two or more plates may be started at once in different trays, and still others started while these are developing. The time for taking out of the developer may be written on a slip of paper placed on top of each tray cover.

Tank Development. By the name, this is a large tank, capable of holding several plates, or several dozen plates, and filled with developer. The developer is at 65 degrees. The plates are put in, left twenty minutes, taken out, rinsed, and placed in the fixing bath. This is a simple method used by professionals and suitable for amateurs. It merely requires care that the developer is standard strength and standard temperature.

In the amateur's darkroom, this tank method operates as follows: Prepare developer according to tank formula; by red light place a plate in a tray and fill the tray with tank developer at 65 degrees; wait twenty minutes; remove plate, wash and fix in the hypo bath. In hot weather, the trays should be cooled to 65 degrees or they will heat the developer; in cold weather it may be necessary to warm them to 65 degrees. This method sometimes is called the *time and temperature* method. With a few plates to develop it is not economical of time nor of developer but the results will average higher in quality than with either sight or factorial method of development in the hands of an amateur.

Developing without the Red Lamp. To develop without the red lamp is merely a matter of *time and temperature,* and handling the plates by touch. By white light, pour the developer into the tray (65 degrees); have the cover at one side and the plate-holder at the other. Put out the light and in darkness remove the plate from the holder, place it in the tray of developer, and place the cover on the tray. Light the white light, look at the watch, wait twenty minutes, remove the plate in white light, rinse quickly and thoroughly and place in the fixing bath. The secret of this process is that white light followed quickly by a fixing bath does not injure the plate.

Washing before Fixing. The plates should be washed before fixing in order to keep the developer out of the fixing bath. The negatives will become stained in the fixing bath if this is not done.

Fixing. The milky silver of the plate must all be removed. To insure this, the plate should be allowed to remain in the fixing bath after the milky appearance is gone for a time half as long as was required to remove the milky appearance.

Fixing after Washing. The hyposulphite of soda must be thoroughly washed out of the film or the negative will spoil with age. An hour in running water, or soaking for fifteen minutes each in six changes of water should insure the complete removal of the hypo. The plate then is set on edge or placed in a rack to dry in a place where dust will not settle upon its sticky wet surface.

Developing Formulas. A convenient method for compounding developers is to open an ounce box of pyro or other developing agent and weigh it all out into quantities each of which will make one pint of developing solution ready for use. These quantities may be wrapped in waxed paper and packed in an air-tight can, bottle, or box. Similar powders of soda may be made up, and when developer is wanted it is necessary only to take one powder from each can and dissolve in a pint of water.

Pyro Developer:

First powder—14 grains pyro

Second powder—80 grains sulphite of soda, anhydrous
55 grains carbonate of soda, anhydrous

For sight or factorial development, take one each of the powders and 16 ounces of water. Temperature 65; factor 12. A normal exposure should develop for about six minutes.

For tank, or "time and temperature" development, take one each of the powders and 36 ounces of water. Temperature, 65; time 20 minutes.

Pyro developer can be used only once except for sight development, and even then it is not advised. It must be used within a few minutes after dissolving but will keep indefinitely before dissolving.

Hydro-Metol Developer:

First powder— 14 grains metol
14 grains hydroquinone

Second powder—104 grains sulphite of soda, anhydrous
104 grains carbonate of soda, anhydrous

Dissolve separately one each of the powders in 8 ounces of water; pour together, making 16 ounces of developer for sight or factorial development. Temperature 65; factor 15.

For tank, add water to make 36 ounces of developer; temperature 65; time 20 minutes.

Hydro-metol developer may be used repeatedly for sight development, but works more slowly after the first use.

Plain Hypo Fixing Bath:

4 ounces hypo crystals
16 ounces water

This bath will keep indefinitely until used, but will not keep after it has been used. It may be used for several plates but works more slowly after the first. Wash the plates well before putting them into the plain hypo bath, for a little developer in the plain hypo will stain the plates if they are left in the bath long.

Acid Hypo Fixing Bath:

16 ounces water
4 ounces hyposulphite of soda, crystals
80 grains sulphite of soda, anhydrous
60 grains powdered alum
1 dram citric acid

Dissolve completely the hyposulphite and the sulphite before adding the alum and citric acid, or the bath will be milky and less efficient.

The acid fixing bath will keep before and after using. It may be used repeatedly as long as it will dissolve the silver from the film, but it works more slowly after the first use. It is less likely to stain the negative from developer, but will do so if too much developer gets into it, and after it becomes weakened with repeated use. It should not be used after having become discolored with developer, for fear of stains upon the negative.

Removing Pyro Stains. Negatives stained with pyro may be cleared after washing and drying in the usual way by immersing in a bath of

3 ounces iron sulphate (copperas)
16 ounces water
$\frac{1}{4}$ ounce sulphuric acid
1 ounce powdered alum

Wash and dry as after fixing. The pyro negative has an olive green natural color which adds much to its good printing qualities. This color is not a stain, and should not be removed. The copperas clearing bath will remove the yellow blotches which sometimes appear on pyro negatives because of developer in the fixing bath.

Intensifying a Negative:

First solution—120 grains mercuric chloride
120 grains potassium bromide
12 ounces water

Second solution—1 ounce sulphite of soda
8 ounces water

Soak the negative in the first solution until it is white, then wash thoroughly and soak in the second solution until it is as dark as desired. Wash thoroughly and dry.

Reducing a Dense Negative:

32 ounces water
1 ounce hypo
15 grains of red prussiate potash

Dissolve the hypo completely in half the water; dissolve the potash in the remaining water; and pour the potash into the hypo.

Reducing Contrast in Negative:

8 ounces water
3 grains permanganate of potash
6 drops sulphuric acid

Intensification. When the shadows of a negative are only gray, either because of too short exposure or too short development, or because of too long exposure and consequent very short development under the sight or factorial system of development, the printing quality of the negative may be improved by intensification by the mercury process, provided always that the negative is not spoiled by the amateur efforts at intensification. Intensification and reduction of negatives should be avoided by mastering the art of exposure.

Reduction. When the entire negative is too dense, use the potash reducer. When the clear portions print satisfactorily but the dark portions are too dense, giving too much contrast in the print, use the permanganate reducer. Except with skill, the negative may be ruined with either. It is well to experiment on a few negatives of small value before attempting either reduction or intensification of a precious picture—and make a few prints from the negative before risking it by intensifying or reducing.

Retouching and Spotting. Retouching consists of working upon the negative, usually with pencils, to improve its quality or to modify the image. First, varnish the negative with a good retouching varnish. Then, working with a fine pencil point, a dark line in the print, as a wrinkle in a face, which shows as a light line in the negative, may be so penciled over that it is much reduced in the print or does not show at all. Retouching is a task which usually requires special training and much skill.

Pin-holes. Small transparent spots sometimes appear in a negative, resembling pin-holes in appearance, due to defect in the gelatine of the plate, to grains of dust on the plate during exposure keeping the light from striking the plate under the dust grain, or to air bubbles clinging to the plate during development. These may be blacked in by a weak solution of India ink applied with a small camel's-hair brush formed down to an extremely fine point. Several applications of a thin color, just touching the spot with the tip of the brush until the film absorbs the ink, will gradually darken the pin-hole until it matches the part of the negative immediately surrounding it.

An opaque spot on the negative, such as might be produced by a grain of dust caught by the film while drying, or by an overspotted pin-hole, will make a light spot on the print, which then may be spotted out upon each print with India ink in the same manner as upon the negative.

PRINTING

Printing consists of transferring the image from the glass negative to a sheet of sensitive paper, and then rendering the paper insensitive so that the transferred image cannot change. This transfer of the image to the printing paper is effected without changing or injuring the negative, and as many finished prints as are desired may be made from one negative.

The negative is not a reproduction of the view, but a record of the image in reversed or "negative" form, with the lights of the view showing dark and the shadows showing light. The print is made from the negative by the use of chemicals which discolor when acted upon by light, giving a shadow in the print where the negative is clear, and a high light where the negative shows dark. The print thus is a "negative of a negative," and shows the view in its proper relation of light and shade.

Processes. Four processes of printing, or producing positive pictures from photographic negatives, are in general use:

(*1*) Printing-out toning processes;
(*2*) Printing-out self-toning processes;
(*3*) Developing or gaslight processes;
(*4*) Enlarging or lens-printing.

In each case, the process consists of subjecting a sheet of sensitized printing paper to the action of light which has passed through the negative, then "fixing" the print thus made.

Printing Frame. The printing frame consists of two parts, frame and back. The frame is open, with a rabbet of proper size to take the glass negative as a piece of glass is placed in a picture frame. The back is in two parts, hinged together, each part having spring clamps for fastening it into the frame. The negative and then the print paper are put in the frame, the back is put on, and the clamps closed. The loaded frame is placed in the sunlight and the printing paper is discolored by the light passing through the negative. By unclamping *one part* of the back and opening it on its hinge carefully, the progress of the print may be observed. The remaining clamped part of the back holds the print paper and the negative in alignment while the free end of the print is looked at.

Printing-out Papers. These papers are so called because the pictures "print out" or become visible while the paper is printing in the sun. The printing paper consists of a sheet of paper with a film on one side, similar to the film of a glass plate, but very much less rapid, or less sensitive to light. In handling it, the red light is not required, as ordinary gas light or the light of an oil lamp does not affect the paper. Subdued daylight, as in a room with the shades drawn, usually is safe and does not affect the printing-out paper.

Chloride Papers. The usual "silver" paper consists of chloride of silver held in a surface of gelatine, collodion, or albumen. It requires the three steps of printing in the frame, toning in a gold bath, and then fixing in hypo, in addition to many wash waters, to produce the finished print ready for mounting upon a card.

To print, lay the printing frame face down, lay the negative in the printing frame with the film side up, lay the piece of printing paper on the negative with the sensitive side down, then a pad of half a dozen pieces of newspaper cut the right size, then put in the back and fasten the clamps. When thus filled, place the frame in the strongest light possible—direct sunlight is best—with the glass side toward the sun. The progress of printing may be watched by looking at one half of the print from time to time, opening the frame and turning back the end of the print, as shown in Fig. 28. This examination must be made in the shade, at least with the frame held in the shadow of the operator's body. Continue the printing until the picture is much darker than desired in the finished photograph. Print until the details in the half-tones have disappeared, indeed until the print seems spoiled. It will fade back in the toning, fixing, and washing to give what is wanted. The degree of over-printing can be learned only by experience and practice.

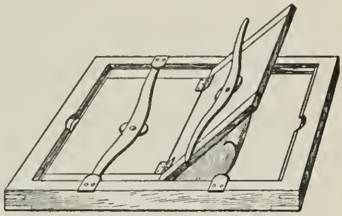


Fig. 28. Printing Frame Open for Inspection of Print

There are many different brands of paper offered by manufacturers, and the explicit instructions which accompany each package of printing paper should be followed. At first, use a toning bath bought ready mixed, if it can be bought especially prepared for the particular paper used. The formulas which follow are representative, and are adapted for most chloride printing-out papers.

Washing before Toning. Place the prints in running water or wash through several changes until the wash water no longer shows milkiness. The silver unaffected by light will be washed out. The prints will get lighter and reddish in color. Keep the prints moving while in the wash water.

Toning. Make two stock solutions.

Gold Solution

$7\frac{1}{2}$ grains pure chloride of gold
8 ounces pure water

or 15 grains chloride of gold and sodium may be used instead of the pure chloride.

Soda Solution

Pure water
Bicarbonate of soda to saturate

By *saturation* is meant to put into the bottle of water all the soda crystals it will dissolve.

For a dozen 4 by 5 prints, shake the bottle of gold and take one-half ounce of the solution and eight ounces of water, place a piece of red litmus paper in it and add the soda solution drop by drop until the litmus paper begins to turn blue. If the litmus paper turns blue too rapidly, add a drop or two more of the gold to slow it. A fresh piece of litmus paper should show slight blue at the end of one minute. This toning bath must be nicely balanced between the gold and soda, and then left for half an hour to ripen before using. Mix the toning bath, and let it ripen while washing the prints. Place the washed prints in the toning bath and keep them moving.

Stopping. The prints will change in color through a range of browns to purple or black. They may be stopped brown or at any shade desired. When any print has reached its desired shade, change it to the stop solution.

Stop Solution

1 ounce table salt
1 gallon water

Fixing. When all prints are toned and stopped, place them in a fixing bath and keep them moving for twenty minutes. The alum fixing bath is preferable.

Soda Fixing Bath

1 gallon water
1 pound hyposulphite of soda

Alum Fixing Bath

1 gallon water
8 ounces hyposulphite of soda, crystals
3 ounces alum, crystals
½ ounce sulphite of soda, crystals
1 ounce borax

Dissolve the borax in a pint of hot water. Dissolve the remaining chemicals in the remaining water, then pour in the borax solution. This bath must be made up the day before it is needed. It keeps indefinitely both before and after using but should not be used after fixing two dozen 4 by 5 prints to the pint.

Final Washing. After fixing, the hypo must be thoroughly washed out or the prints will become discolored with age. Wash for an hour in running water, or for two hours in changing water, changing the water at first every five minutes. To change the water on the prints, use two dishes, lifting the prints one by one from the first dish into the second, with a moment of draining.

Combined Toning and Fixing. Two stock solutions are required, soda and gold.

Stock Soda Solution

8 ounces hyposulphite of soda, crystals
6 ounces alum, crystals
2 ounces granulated sugar
2 ounces borax
88 ounces water

Dissolve the borax in a half-pint of hot water; dissolve the remaining chemicals in the remaining water, cold, and pour in the borax. Let stand over night and pour off the clear liquid.

Stock Gold Solution

7½ grains pure chloride of gold
64 grains acetate of lead
8 ounces water

Fifteen grains chloride of gold and sodium may be used instead of the pure chloride of gold. Do not filter. Shake before using.

For fifteen 4 by 5 prints, take 8 ounces of stock soda and one ounce of stock gold and put in the dry, raw prints without washing before toning. When properly toned, stop them in a solution of 1 ounce of salt and 1 quart of water. Then if possible use the acid fixing bath for ten minutes to ensure thorough fixing. Wash finally for an hour in running water, or the equivalent in changing waters.

The formula given for the combined toning and fixing bath is a thoroughly tested one, and may be bought ready mixed under the name of "Solio Toning Solution."

Self=Toning Paper. These are printing-out papers which take a brown tone without the use of the gold toning solution. Their manipulation is much simpler than the ordinary printing-out papers. Some of them require only washing in water to tone and to render the print permanent. Others require a hypo solution, but in all instances the claim of self-toning is justified by the simplicity of the operations required after printing.

Blue Prints. When purchased, the blue print paper has one side coated with a sensitizing solution containing iron. The coated side varies from a light yellow to green in color. When printed under a negative in a printing frame in the sun as with any other printing-out paper, the image comes up a dull dark blue and the shadows change to a gray or bronze appearance. Print until the deep shadows are bronze and until the detail is lost and the print seems spoiled. Then wash in clear water until all the yellow is washed out of the print and dry. Too long washing will lose the details and half tones of the picture. The picture is blue and white, and is permanent.

Sepia. Print as for blue prints, but develop in a very weak solution of hyposulphite of soda before final washing. If the hypo is too strong, the prints will fade in the bath. The sepia print must be placed in the hypo and then in the wash water instantly when removed from the printing frame; it will not "keep" even a few minutes.

Developing Papers. The amateur who is employed during the day will find his time best disposed and will get the most enjoyment out of his photographic occupations by using his holidays in the field with his camera making exposures for new negatives and by making his prints by artificial light in the evenings. The printing papers which are offered for contact printing by artificial light are substantially slow plate films spread upon paper supports. The processes of exposure, development, and fixing are substantially the same. Pyro cannot be used. The hydro-metol formula for developer for plates and the fixing baths either plain or acid are proper for developing papers. The acid fixing bath is preferred. Visual development is entirely satisfactory and factorial or tank development need not be attempted. With normal working and a normal negative, a finished print is in the fixing bath in less than one minute after the negative and paper are put in the printing frame, giving a decided advantage for the amateur over the slower processes of printing-out papers.

The sensitive coating of developing papers is made much slower in response to light than the coating used for plates, so much so that red light is unnecessary. The developing trays may be placed upon a table 6 feet or more from a gas jet, but when developing the operator should stand with his back to the gas jet and with the shadow of his body falling over the developing tray. The paper should be kept covered or wrapped in black paper before printing, and should be loaded into the printing frame in the shadow of the operator's body.

The printing outfit required consists of a printing frame, Fig. 28, and three developing trays. Place the three trays in a row, developer in the left, water in the middle, and fixing bath in the right. The trays are very convenient if of a larger size than the prints to be made, and the quantity of solutions contained must be liberal. Each print passed through the developer consumes some of the strength of the solution, thus weakening it, and if the quantity of the developer is small the print may weaken it to such an extent that two prints from the same negative and having the same exposure will develop differently because of the weakening of a small quantity of developer by the first of the prints. A developer may be used repeatedly until it becomes too slow in action.

Developing papers may be printed by exposing the loaded printing frame to daylight, but daylight is so variable from minute to minute, if there are clouds in the sky, that an element of uncertainty and, therefore, an element of failure is brought into the operation of making the prints. Artificial light usually is constant and is preferable for that reason. With a 4 by 5 printing frame, loaded with a medium negative, and held 7 inches from an ordinary gas or incandescent electric lamp, a trial exposure of twenty seconds may be made. Remove the paper from the frame—it shows no image—and immerse in the developer. In fifteen seconds it should be completely developed, and unless transferred quickly to the water it will be over-developed. Rinse for a few seconds in the water to remove the developer from the surface and place it in the fixing bath. After fifteen minutes in the fixing bath, wash and dry. To be able to stop the development at the proper instant upon an over-exposed print, lift the print when development is nearly complete and let the developing solution drain back into the tray. The print will continue developing for a few seconds while held in the air, because of the developer which clings to the surface. At the proper instant, plunge it into the wash water, which will stop development almost instantly, and then into the fixing bath. Turn an under-exposed print face down in the developing tray to avoid fog during prolonged development.

If with a proper exposure the whites of the picture are gray before the shadows are deep enough, the addition of a few drops of a solution of bromide of potassium—1 ounce bromide of potassium dissolved in 10 ounces water—will tend to keep them clear. Too much bromide in the developer will give olive tones to the print. Old and slow developer will give purplish tones to the print. Fresh normal developer, without too much bromide will give pure blacks and whites with untinted half tones throughout the entire range from light to shadow.

The time of development should be about fifteen seconds with normal developer, average negatives, and regular qualities of developing papers. The amount of exposure should be gauged to require this time of development. The length of exposure may be regulated to some extent by the distance between the light and the printing frame. Double the distance for the same negative requires four times the length of exposure, and half the distance requires but one-quarter the length of exposure, but if the printing frame is brought too near the light the center of the picture will be printed darker than the edges and the heat may crack the glass negative. If the length of exposure is shorter than twenty seconds, increase the distance from the light and give a longer exposure. It is very difficult to time accurately an exposure of less than twenty seconds, and by adopting a longer exposure the proper length may be given more accurately. The adjustment of exposure by distance also involves printing a thin negative by weak light and a dense negative by strong light, a rule usually recommended by the makers of gaslight papers. To secure uniformity of illumination over the entire negative, a 4 by 5 frame should not be exposed closer than 7 inches from the light, and a 5 by 7 frame not closer than 10 inches.

Several different brands of developing papers are to be bought in the market, all differing from each other to some extent, and for each brand the manufacturer advises a specific treatment, developer compound, etc. The instructions with the paper should be read carefully until understood.

Lens Printing. In a contact print, the images of the print always are of the exact size of the images in the negative; it is not possible in a contact print to make a print larger than the negative, and it is possible to make a print smaller than the negative only by omitting some portion of the view, such as the margins, the images actually printed being of the size of those of the negative. By printing through a lens it is possible to change the size of the images of the picture, producing a print either smaller or larger than the negative from which it is taken.

Printing through a lens is a process requiring longer exposures or more sensitive printing paper than contact printing, since all

FOOD FOR THE HUNGRY
Scene from Photoplay, "How He Redeemed Himself"
Courtesy of the *Champion Film Company, New York*

SCENE FROM PHOTOPLAY, "THREE OF A KIND"
Courtesy of *Independent Moving Pictures Co., New York*

the light which may fall upon the negative cannot be passed through the negative and lens effectively to act upon the print paper. To bring the time of exposure within reasonable limits, a paper called *bromide paper* is used. This is much more sensitive to light than the brands used for contact printing. When arrangements are made to illuminate the negative by daylight, the use of bromide paper will bring the exposures frequently to less than one minute in length. The length of exposure will depend upon the size of the enlarged picture, as well as upon the size and density of the negative, the diaphragm stop of the lens used, and the intensity of the light.

Bromide paper cannot be handled in daylight or in gaslight, as ordinary developing papers are handled, but must be worked in the darkroom. It is developed and fixed as the ordinary developing papers are, the developing and fixing formulas given for the developing papers being in general suitable for bromide papers, but in the case of the bromide papers the instructions accompanying each brand of paper should also be studied until understood, and if possible the exact formulas which accompany the paper should be used in working the paper. The manufacturer has done all the experimenting necessary to produce good results.

Enlargements. To make an enlargement, a window must be closed with a tight screen having a hole in it a little larger than the negative, and at such a height that the camera may be backed up against the hole to close it. A cloth thrown about the camera when thus placed will seal the window light tight. Cut the middle partition out of a double plate-holder so that when a negative is placed in the plate-holder it will be held by the edges only. Remove the ground glass from the camera, place a negative in the plate-holder and place the plate-holder in the camera. Place a white screen vertically in front of the camera, and focus the negative upon it by racking the front of the camera out to the proper focus. To make the image upon the screen larger, move the screen farther from the camera; to make the image smaller, move the screen nearer to the camera. If the window does not open directly to the free sky, a mirror may be placed outside the window to reflect the free sky into the negative. The arrangement with mirror is shown in Fig. 29. The only light entering the room is that passing through the negative and the lens.

To make a test exposure, place a piece of ruby glass in front of the lens and tack upon the screen a strip of bromide paper. Remove the ruby glass from the lens for one-half minute and cover one-quarter of the strip of bromide. Again remove the ruby glass from the lens for one-half minute and then cover the second quarter of the bromide strip, which now has had one minute. Remove the ruby glass from the lens for one minute and cover the third quarter of the bromide strip, which now has had two minutes. Remove the ruby glass from the lens for two minutes, giving the remaining

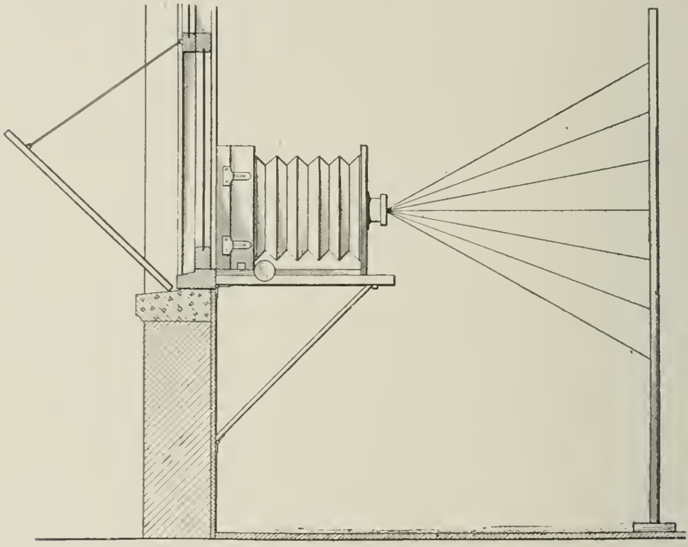


Fig. 29. Camera Arranged for Daylight Enlarging

quarter of the bromide strip four minutes in all. Develop the strip, and it will tell which exposure is correct, or between which two values the correct time will be found. When this is known, tack a full-size piece of bromide paper on the screen and expose for the determined length of time, developing, fixing, and washing the resulting print.

Lens caps fitted with ruby or orange glass may be bought for capping the lens while pinning the bromide paper to the screen for exposure. The advantage of such a colored glass cap is that it leaves the image visible upon the screen and the bromide paper may be correctly placed. This is of particular value when only a part of the whole negative is to be printed in the enlargement.

SPECIAL APPLICATIONS OF PHOTOGRAPHY

Lantern Slides. To tell a long story in a short way, the lantern slide is a print on glass instead of on paper. Lantern-slide plates are sensitized usually with the same chemicals used in bromide paper. They may be printed by contact printing as any developing paper is printed, or may be printed by lens printing. In either case, they must be handled by darkroom methods, because they are as sensitive as the bromide paper and nearly as sensitive (about one-twentieth) as the dry plates used for negatives.

The American lantern slide is always of a standard size, $3\frac{1}{4}$ by 4 inches. Foreign slides sometimes have other dimensions. Upon this size of plate, the actual picture for projection by the lantern seldom is larger than $2\frac{3}{4}$ by $2\frac{3}{4}$ inches. Where the image to be printed upon the lantern slide is contained within this space in the negative, the slide may be printed by contact, but where the image in the negative is larger than 3 by 3 inches, it will be necessary to employ the process of lens printing. As the lantern slide is but a bromide print on glass, all of the instructions for lens printing on paper apply directly to the making of a lens-printed lantern slide. The lens printing of the lantern slide will be necessarily "copying down" or reducing rather than enlarging, meaning that the screen upon which the picture is focused will be closer to the lens and will require a longer draw for the camera bellows. If necessary, a box with both ends open may be introduced against the window, holding the negative against the window, the back end of the camera being against the other end of the box, thus providing an extension to the length of the total draw obtainable by the box and the bellows together. Correction for the thickness of the glass of the lantern-slide plate must be made to secure proper focus, but a ground glass may be focused upon and the slide plate substituted for exposure.

Another method of lens printing for lantern slides when the reductions are considerable, is to place the lantern-slide plate in the plate-holder of the camera, place the negative in the window, and focus the ground glass of the camera upon it with the lens end of the bellows toward the negative, inserting the lantern-slide plate with the dark slide and exposing as in a field exposure, thus actually making a photograph of the negative.

Place a lantern-slide mask upon the completed glass print, place a cover glass over it, and bind the edges with lantern-slide binding strip, and the slide is finished.

Stereographs. These double pictures are adapted to present two slightly different images of the same object to the two eyes when viewing the stereograph, the two images being different in just the details wherein the two eyes of the observer would see the physical object differently by reason of the difference between the viewpoints of the observer's eyes. The two pictures of the stereograph are made simultaneously by a camera having two lenses side by side. A two-image negative thus is produced, a two-image print is made from it, and the two images are cut apart and pasted upon a card for viewing through the lenses of the stereoscope. By reason of the lens reversal of the images in the camera, the images of the print must be transposed before pasting upon the card. The distance between the lenses usually is about $3\frac{1}{2}$ inches; between the prints on the stereograph mount, about $2\frac{3}{4}$ inches. This gives a slightly exaggerated perspective, increasing the illusion of perspective and solidity when the stereograph is viewed properly. While the paired lenses are desirable, stereographs of still objects or scenes may be made by an amateur by two successive exposures of the same camera, the camera being moved 3 or 4 inches between the two exposures. Use a small lens stop, as great depth of focus is desirable in a stereograph.

Panoramas. The ordinary photographic lens places upon the ground glass an image which includes about sixty degrees of the horizon. *Wide-angle* lenses are lenses of short focus for comparatively large plates and sometimes cover one hundred degrees or more. Negatives including more of the horizon than any single fixed lens can make have been obtained by a swinging lens. A camera of this nature has a sensitive film held in a semicircle, and has its lens mounted in a swinging frame which gives an exposure of but a narrow vertical slit upon the film. As the lens swings, nearly one-half of the horizon is impressed upon the film in a continuous image. Another type of panoramic camera has gears for revolving it upon the tripod top and winds a roll of film behind the slit of a lens while the camera is revolving. With this camera an image may be made including the entire horizon.

Panoramic prints may be made by the amateur by making two or more plate exposures and pasting the prints upon a card with the edges carefully trimmed and matched. In making such exposures intended for panoramic mounting, the vertical line of matching should be in mind when arranging the image upon the ground glass. Only the double lens should be used, as the distortion of the single lens will be seen when the edges are matched in the finished picture.

Telephotography. Quite the opposite of panoramic photography is telephotography, which is the art of enlarging a small portion of the view to fill the entire plate. The production of a large image of a distant object is the result which telephotography endeavors to obtain. This is done directly in the camera by adding a third lens cell to the double lens; a negative cell, having a lens thinner in the middle than at the edges, spreads the middle part of the image to cover all of the plate. The arrangement of glasses in such a lens is shown in Fig. 30. The third, or negative, lens is mounted at the back end of a long lens tube and an ordinary double lens is mounted at the front. By the use of the telephotographic lens, a bellows extension of 12 inches may be sufficient to make an image upon the ground glass as large as would be made by a lens of 48 or 60 inches in focal length. The time of exposure, however, is proportionately longer, and the enlarged image upon the ground glass is proportionately dim. Telephotography is a process for the enlargement of the image in the camera before it is recorded. The result does not differ from an enlargement made from a small portion of a negative taken from the same viewpoint, unless in greater sharpness of detail.

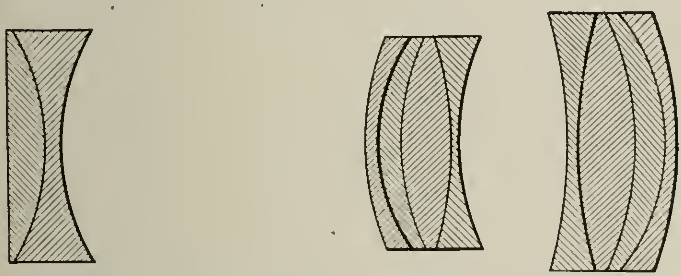


Fig. 30. Glasses of a Telephoto Lens

Orthochromatic Photography. White light is made up of a mixture of colors, and colored objects are objects which separate the white light which falls upon them and give to the eye but a part of its component colors. Of all the visible colors, the blue and violet are the most active in affecting the photographic plate. There are also invisible rays, called *ultra-violet* rays, accompanying white light which are very powerful to affect the sensitive plate. With the blue light more powerful in action upon the sensitive plate, it is clear that when an exposure is made upon a subject containing blue, yellow, and red, as a bouquet of flowers, the light from blue blossoms will make a darker image in the negative and, therefore, a lighter image in the print than light from the red or yellow blossoms. Thus, a scene having colors will not be reproduced in its proper light and shadow values by the ordinary processes of amateur photography. A rosebush in bloom with white roses will give proper results, but an adjacent bush in bloom with red roses will appear in the photograph to have no blossoms at all, since the bright red of the blossoms is no more effective upon the sensitive plate than the dull green of the rose leaves, and the roses may be distinguished upon the bush only by their shape, as green apples upon a midsummer tree.

To remedy this feature of the ordinary photographic processes and to render photography suitable for colored objects, a plate sensitive to yellow and slightly sensitive to red is made, and there is made also a colored screen, or "ray filter" for the lens which has the faculty of holding out a large portion of the blue and ultra-violet rays and permitting all of the yellow and red rays to pass. When such a plate, called an *orthochromatic plate*, is exposed to a lens image of light which has passed through a proper ray filter, the blues, yellows, and reds will all have equal effect upon the plate, and the resultant picture will show the view, not in colors at all, but in proper values of light and shade regardless of color in the view. The objection to the universal use of the orthochrome plate and the ray filter is that from three to eight times the exposure is required.

Colored Photographs. Any print may be colored by brush and suitable transparent dyes. If it is the wish to reproduce the actual colors of the scene, it is necessary that the negative be made with an orthochromatic plate, or it will be impossible to reproduce the reds, since they will be black in the print. Photography in natural colors by camera and development processes without recourse to hand coloring is a problem which has been solved in several ways, yet no solution is entirely satisfactory. The most nearly satisfactory processes involve *first,* the separation of the light of the image into two, three, or four different colors; *second,* the photographing of the separate colors by separate negatives, the negatives being uncolored; *third,* the making of prints, one for each negative and each print of a single color in itself but of a color different from the other prints of the set; and *fourth,* combining the separately colored prints or arranging them in a viewing device such that all of the prints may be viewed at once. The colors, thus being placed upon each other, blend in the eye to form all the hues of the original view.

Tri-Color Photography. Pieces of orange-red, green, and violet glass are required, of such size as to cover the lens of the camera. Tri-color results will largely depend upon the accuracy and purity of the hue of these colored ray filters. Having selected and focused the scene, expose three orthochromatic plates, one after another, each of them with one of the colored glasses in front of the lens. With a set of color filters used by the author, the exposure required is four times normal with the violet filter, thirty times normal with the green filter, and five hundred times normal with the orange filter. The negatives when developed will all look alike. Make three lantern-slide plates and cover each with a cover glass of the color through which the negative of that slide was made. In all slides, white objects are clear glass; shadows are black. Brightly colored objects remembered in the view will have different half-tone values in the three plates. A violet object is lightest in the violet plate. A blue object is darkest in the orange plate. A green object is lightest in the green plate. A yellow object is darkest in the violet plate. A red object is lightest in the orange plate. The three slides are projected by three lanterns upon the same screen and at the same time, when the colors will unite to give all the hues of the original view. The process is simple in theory, but requires very careful and accurate working to produce acceptable results.

Autochrome Plates. By the use of these plates an amateur may make pictures in natural colors as simply as making a negative and paper print. Each exposure in the camera produces not a negative but a glass positive print in colors, suitable for direct view or for lantern slide if of proper size. The exposure is made through a special orange screen, and the time of exposure is about one hundred times the normal exposure for the same view and lens stop with ordinary plate and no ray filter.

Autochrome plates differ from ordinary plates by having interposed between the sensitive coating and the glass a thin layer of transparent microscopical starch grains, dyed orange-red, green, and violet, spread without over-lapping, and mixed in such proportion that the layer appears colorless. The sensitive coating is extremely thin, and made of a very fine-grained emulsion. When such a plate is exposed in the camera, the glass side toward the lens, the light before reaching the sensitive coating passes through the colored starch grains, which act individually as minute color filters, each one absorbing all colors but its own. A microscopical selection takes place, and after development there will be found under each grain a corresponding black image of a density proportionate to the amount of color received and transmitted by this particular grain. Were the plates fixed at this stage, the picture when examined by light passing through the plate would show only the colors complementary to those of the original, since the true colors are masked by the black images they created beneath the grains. The next step is to dissolve the black silver by an acid permanganate solution; then the plate is exposed to white light and re-developed, blackening the white silver left by the permanganate solution. The image now is reversed. Each color grain transmits light precisely of the same hue and proportionate intensity as the light transmitted by the grain when the exposure was made in the camera, and the view is seen in its natural colors.

SCENE FROM PHOTOPLAY, "THE ROSE OF OLD ST. AUGUSTINE," OR "A TALE OF JEAN LAFITTE, THE PRIVATEER"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

SCENE FROM PHOTOPLAY, "VAN BIBBER'S EXPERIMENT"

Courtesy of Thomas A. Edison, Inc., Orange, N. J.

MOTOGRAPHY

Motography, or motion photography, is compared with fixed or still photography at every point. It is contrasted with fixed photography in three important phases: *First,* the product desired; *second,* the methods of production required, which involve the author of the film story and the producer, with their assistants; and *third,* the means adopted, which involves the photographer and his specialized photographic equipment.

PRODUCT DESIRED

Fundamentally, motography is the art of depicting motion by means of photography. Usually the associated step of projection is used for viewing the motion depicted in the motion-picture film, but with this the photographer of the motion picture is hardly concerned. His picture when completed may be viewed by projection, or by direct vision in a proper stepping device, or by close and careful study of the successive pictures, either alone or with two consecutive pictures placed over each other to reveal the differences due to motion in the subject. Motion pictures may be made for scientific study or for purposes of amusement.

Chronophotography. In this word, "chrono" means "time," and the object of the art of chronophotography is to photograph the condition of a moving subject at successive times in its movement. Such a process would produce if possible a sharp photograph of the subject at regular intervals, so that a careful study of the series of pictures might reveal just what changes had taken place in the short interval of time between the taking of two successive pictures. The extreme positions taken by the subject and the positions of the subject at critical instants may be observed in such a series of pictures, enabling a scientist to study his subject in a manner that is hardly possible by any means other than chronophotography.

Chronophotographic machines have been devised to make pictures at a rate as fast as five hundred pictures of the same subject in one second. With a flying bird beating its wings at the rate of two beats per second, such a photograph would present two hundred and fifty different positions of the wings of the bird in beating the air, and certain of the images would show the extreme upper, the extreme lower, and the extreme outward positions of the wings, as well as showing the difference in positions of the wings in beating downward upon the air and in returning to the upper position. These photographs should be sharp and distinct as far as possible, that even the details of the wing feathers may be studied. Such a series of photographs should be of value to a student of flying machines, but it is not recorded that any such good has come of it.

In the study of a walking man, chronophotographic studies have been made by the military department of France and, as a result of those studies and experiments conducted in connection with them, it has been found possible to increase the endurance of infantry on march by teaching the soldiers an improved marching gait.

In chronophotography, it is desired to photograph the subject *as it is* rather than as the eye sees it, for because of its motion the eye of the observer may be deceived as to the actual positions taken and as to their actual order of occurrence. It is the object of chronophotography to reveal for the study of the scientist that which the eye is unable to see.

Kinephotography. This is an older name for motography. In this word, "kine" means "motion," and the object of motography is to make a record of the motion of the subject in such a manner that by the use of the record the motion may be reproduced to the eye viewing the picture.

In motography, it is desired to photograph the subject *as the eye sees it* rather than to reveal it as it is, and if because of the motion of the subject the eye is in any way deceived when viewing the physical subject, then the true artist motographer will produce such a picture as will also deceive the eye in the same way and to the same extent when viewing the motion picture.

The making of motion pictures is thus divided into two classes: motion pictures for scientific study—chronophotography; and motion pictures for amusement—motography—for motography is so largely an industry of amusement that its other phases may be considered as subordinate. Chronophotography will be considered later as a subordinate phase of motography.

Subjects. Primarily the proper subject for a motion picture is motion, or a subject containing motion. This is not a limitation, however, for still subjects are very forcibly presented in motion pictures when the camera itself has movement so that each of the successive images upon the film is made from a different viewpoint.

Subjects are classified in the trade as travels, industrials, current events, dramas, comedies, and trick pictures. Travels, industrials, and current events, are pictures in which the motographer finds his subject ready for his camera. It is necessary only to choose a viewpoint for the camera, and to choose an opportune moment, particularly for proper lighting, or if an interior is involved it may be necessary to provide artificial lighting. Dramas, comedies, chases, and trick pictures on the other hand are classes in which the motographer must create his subject. These form the bulk of the film industry and occupy the picture screens of the motion-picture theaters almost exclusively. These classes overlap each other, while science studies are a class apart. In many instances, a film picture might be classified in either of two or even more classes, according to one's own judgment.

Travels. Travels include pictures showing the natural scenery of the country as the chief interest of the picture. The title takes a form indicating a journey or a visit to a country or place. The film is made up of many scenes, as though the motographer were enjoying a holiday with his camera and were photographing everything of interest to him, particularly everything typical of the place or country in which his visit is made, or of the line of travel over which his journey carries him.

Industrials. Industrials are in substance similar to travels, the distinction being rather that the one takes the work of man as a subject and the other takes the work of nature. An industrial picture shows the production of something involving the industry of man. Factory industries when made the subject of motion pictures may include the production in the mine, farm, or forest of the raw material; views of the machinery with which the raw material is worked through its various stages of manufacture; views of the material itself in its successive stages of manufacture; and views of the finished product. Mining, farming, lumbering, and shipping, when made the subject of industrial motion pictures, verge upon the classification of travels. A decision as to whether the picture should be classified as travel or industrial should be based upon the manner in which the motographer has handled his subject.

Current Events. Current events are substantially news pictures. Whether an event of interest becomes a part of a travel picture, an industrial picture, or a current-event picture comparable to a newspaper illustration, depends largely upon the manner in which it is handled. "A Visit to London" (travel) may properly include views of water sports on the Thames; "The Ice Industry" (industrial) may open with a scene of skating on the ice and close with spectators consuming ice-cold beverages while they watch a tennis game; a professional ball game or a prize-fight seems "industrial" within itself; "The Funeral of King Edward VII.," a splendid and impressive film, is properly classified as a news picture (current events).

Dramas. Dramas are pictures which have a story to tell. They are comprised of a series of connected incidents which tell the story step-by-step—as a staged production in pantomime—yet do not contain the element of levity or burlesque to such an extent as to render the film classifiable as a comedy. The main object of the drama is to tell a story in a pleasing manner and in such a way that the story forms the fundamental feature of the entertainment, and not the actors, nor the stage setting, nor the separate incidents.

Comedies. Comedies are pictures which are designed to tell a story with the sole intent of creating laughter. When in the nature of drama, the plot and its execution by the actors is light or burlesque in nature. Pictured jokes, pictured puns, pictured accidents with ludicrous results, awkwardness and confusion on the part of the actors, all furnish subject matter for this class of film pictures.

Chases. Chases are a division of the comedy class, in which the story involves the pursuit of some of the actors by others. A long series of ludicrous incidents may be strung together in a film, depicting the efforts of the pursued to evade his pursuers and the tribulations of the pursuers, ending the film either with or without a capture.

Trick Pictures. Trick pictures are based upon the ability of the motographer to deceive the audience with film pictures produced by special manipulation of the motion-picture camera. Trick pictures usually are comedies in that the trick-picture art usually is used to produce laughter. Under this class, however, come pictures of transformations forming parts of more serious dramas, and some trick pictures themselves are wonders of illusion so profound that they have a charm of their own and offer a class of entertainment neither drama, nor comedy, nor chase, and classifiable only as "trick" or "spectacular."

METHODS OF PRODUCTION

Early Methods. *Drawn Pictures.* Motion pictures are almost as old as pictures, but until the advent of photography the motion picture was nothing but a scientific curiosity or a toy. The oldest motion-picture device of which we find record is the *zoetrope*, Fig. 1, a whirling device having a number of slits in a cylinder, and opposite each slit a picture. As the cylinder whirls, the pictures are seen in rapid succession, and the whirling may be so rapid that the pictures seem all piled upon each other. When the device is turned at proper speed, persistence of vision holds one picture until the next is seen. By drawing the pictures by hand, taking care to simulate successive positions of an object, the object will seem to have motion when the device is whirled and the pictures are seen successively.

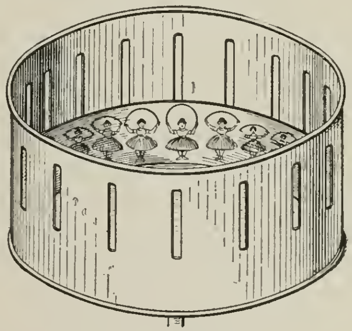


Fig. 1. The Zoetrope

Since the advent of the first picture-viewing device and before the advent of photography, a large number of designs of viewing or even of projecting apparatus for motion pictures had been produced, but no devices for making the pictures to be viewed. The making of the many pictures by hand was a well nigh impossible task. In such a series, the fixed objects must be exactly alike in all of the pictures of the series or there will seem to be motion in the fixed things of the picture. The moving objects must be similar in all details and must vary in position only, and the variation in position must be in harmony throughout all the moving objects of the scene. A compromise was effected by one progressive experimenter, who projected his fixed objects from a fixed lantern slide and projected upon that fixed scene his carefully drawn moving images. In this way he simulated the entrances, gestures, and exits of actors upon a stage setting, and in the light of more modern history it is but reasonable to think that perhaps he supplied also spoken words for the actors, thereby anticipating in a measure the modern "talking pictures."

Photographic Process. With the discovery of photography came the realization that here was a new agent for the production of pictures for the moving-picture exhibiting apparatus. The difficulty to be met was in photographing moving scenes with photographs taken in such quick succession that the movement between two successive images would be so small that the two images would seem to blend into one as the hand-drawn pictures of the zoetrope did when the new photographs were substituted for the old hand-drawn images.

Separate Cameras. The first solution was by Muybridge who, in 1877, arranged a row of twenty-four cameras with string-trigger shutters, the string of each shutter being stretched across a race track. A horse rapidly driven down this race track broke the strings and released the shutters as the horse was opposite each camera, thus taking a series of pictures within a very short period of time. When these plates had been developed and compared and matched up, it was found that a set of them could be arranged to show the successive positions of the running horse. This set comprising only a limited number of images was suitable to be shown in any of the motion-picture viewing devices then known.

Multiple Camera. The next solution was that of LePrince, about ten years later, who arranged a multiple camera. This, in substance, was a battery of sixteen automatically reloading cameras, using strip film. Each camera would make one picture and while the remaining fifteen cameras were making fifteen more pictures in regular sequence, the first camera would automatically bring a fresh film into position to make the seventeenth picture in its turn, and so repeatedly the sixteen cameras would operate to make a con-

THE OUTLAW MAKING HIS GET-A-WAY
Scene from Photoplay, "The Outlaw and the Child"
Courtesy of *Essanay Film Mfg. Co., Chicago*

HE'S MY SWEETHEART
Scene from Photoplay, "In the Great Big West"
Courtesy of the *Champion Film Company, New York*

tinuous series of photographs. This LePrince camera was the immediate ancestor of the modern motion-picture camera, being built in a single case with battery of sixteen lenses and sixteen shutters, all operated by a single continuously turned crank. The pictures were taken upon four strips of film. By printing four positive strips and passing them through the same battery of lenses and shutters, projection could be accomplished, or the pictures could be cut apart and pasted into a single strip such as is used in a modern projecting machine.

Modern Methods. The features of the modern motion picture which are improvements upon the earlier forms and which render it adaptable for its present amusement purposes are the production of the images by photography; the flexible negative film which permits a large number of pictures to be taken quickly in succession upon a single strip of negative record; the transparent support for the positive print or positive film, permitting the picture to be projected in an enlarged scale upon a screen so that it may be viewed by large audiences; and the system of registering holes in the margin of the films by which registry or alignment of the numerous pictures of the series is attained in the projecting machine.

Motion pictures were fully reduced to a commercial entertainment means when it was possible to take a motion camera and a reel of negative film, to select a subject and expose the film upon the subject, to print the negative upon a strip of positive film and produce a positive print, and to project that print upon a picture screen to be viewed by an audience. They were well received by the public from the beginning, and the industry grew rapidly from the first.

In the beginning it was sufficient to photograph anything with movement, and the wonder of the projected picture was sufficient to hold the attention of the audience. A railway train passing, a fire engine, a waterfall, or the view from the car window was sufficient. The subjects, which were confined to "travel" and science studies, and occasional comedies, were enthusiastically received by the public. Dramas were not known.

With the advent of the exclusively motion-picture theater, the demand for drama and comedy grew. It became necessary for motion-picture manufacturers to acquire studios suitable for staging drama and comedy, to employ writers to furnish themes for motion-picture plays, to employ actors and stage directors to present the themes properly before the motion camera, and to employ scene painters and property men in a manner very similar to the operation of a standard theater except that the seating capacity is absent and the play is produced but once in the studio.

Division of Labor. When an industry has reached such a magnitude that many people are employed in its work—Pathé Frères have more than five thousand employes in France—some employes will develop greater ability in some lines than in others, and the lines of activity become so divergent that they are best cared for separately. As in any manufacturing industry, the manufacture of motion-picture films for exhibition in a modern factory has its division of labor, and a film picture is the joint product of the various departments and specialists who in turn take it and perfect it with their skill. Four widely different classes of ability are involved, represented by four men, the author, the producer, the salesman, and the photographer, with their assistants.

The author's stint begins with the conception of the thought and continues until the thought is reduced to motographable form. The "producer" takes charge of the total task at that point and carries the work forward until the motographic scenes of the picture have been recorded upon the sensitive film by the photographer. The photographer's duty comprises the carrying of the camera to the producer's scenes wherever they may be, recording the scenes photographically, developing the negatives, and printing as many finished pictures as the salesman may require. The salesman most likely will be called the advertising manager of the film manufacturing company, but his ultimate duty is to sell the film product which the author, producer, and photographer have worked together to make.

THE AUTHOR

For the production of travels strictly, as travels were produced in the early days, perhaps no author is required. The modern tendency toward drama has modified the custom. It is in dramas, comedies, chases, and trick pictures that the author becomes prominent, and as these form the bulk of the motion-picture industry the author is always first to be considered. Much special training is necessary to become a successful motion-picture author.

His Problems. *Limitations of the Art.* The limitations of the producer must be understood fully by the author. Few fiction writers create a successful drama for the histrionic stage at the first attempt, and their failures are due largely to a lack of knowledge of the limitations, of the technique, of the dramatic stage. Much more limiting are the requirements of the motion-picture producer with his studio stage and voiceless actors.

Many ambitious writers have submitted stories to the film manufacturers in the hope that they might be found suitable for production in motion pictures, but very few of such stories are acceptable. The film manufacturer is still obliged to create his own plots, to write his own stories and scenarios, and to employ persons who have become trained to authorship under the limitations exercised by the producer and the tools he has to work with. Any limitation upon the maker of the film must of necessity be also a limitation upon the writer of the story which is to be told by the film. One limitation is the matter of color, for, unless the story is to be written especially for color production, no essential part or feature of the story or action may depend upon color. Another limitation is time of action, with an upper limit of twenty minutes or one reel of 1,000 feet of film for drama, and usually ten minutes or a half reel of film for comedies or trick pictures. Other limitations are the size of the stage which may be used, the costumes, stage settings, and stage properties, and last and most important of all the necessity of conveying thought by action, gesture, and facial expression rather than by voice.

Plot. The author must deliver an acceptable plot. The proper plot for a motion picture is one suitable for a short story of one thousand words in the current magazines rather than one suitable for a popular novel. The complete action must occur in twenty minutes, and this compels the story to be told as a short story, no matter how much there is to tell. The masterpieces of motion-picture drama consist of simple stories, simply told. The rule carries into comedy, trick, travel, and industrial pictures. A central thought forms the foundation of the story; this is embodied in a series of incidents involving as few leading characters as possible, for it is confusing to the audience to be obliged to carry too many characters in mind. An unnecessary character only confuses the spectator and leads the attention away from the principal characters and from the central thought which they are to give. The series of incidents should require as few stage settings as possible, for the same reason that multiplicity leads to confusion and confusion is undesirable. The time is short, twenty minutes, and the real story of the play must be told fully and plainly, not smothered with unnecessary scenes or incidents nor obscured with side thoughts. Lubin's "Woman Hater" offers a twenty-minute picture of a thousand feet of film staged with a single stage setting and only four characters, and it is one of the masterpieces. Essanay's "Justified" does the same with only three characters and a couple of supes.

The plot is brief. It is only the central idea, the skeleton, the foundation. The title is not the least in importance, for it is the part which is advertised outside the theater and the detail upon which dependence is placed to draw the patrons from the sidewalk past the ticket window into the house. When a striking title is created in the author's mind, the plot is half written.

Scenario. The scenario elaborates the plot into "dramatized" form, for the motion-picture play should be written as if for the stage, not in "fiction" form as for a magazine article. In the scenario, the characters are listed, the required scenic settings are listed, and the action scene by scene is recited. "Titles" are given in the order in which they are met from scene to scene. Under the name of "titles" are included notes written, newspaper pages, or any matter which the audience must read in the progress of the picture.

SPECIMEN DRAMA SCRIP

The following typical drama with but four leading characters was produced by the American Biograph Company. The scene settings are simple, only three scenes being set for studio, and those not requiring anything unusual in the way of scenery. The outside scenes are such as may be found in any village. That one scene setting is used several times and the total number of scenes thus increased is not objectionable. The plot will withstand successfully a rigid analysis. The drama is divisible into four chapters, as the four acts in a staged play, each chapter having a definite part in the progress of the telling of the story. No scenes of crime or violence are involved, and no scenes of a nature to depress the spirits.

TITLE

A Midnight Cupid

PLOT

A tramp wanders into a club man's rooms and falls asleep. Club man, bored with society, finds tramp and finds in tramp's pocket letter asking tramp to return home. Club man for diversion assumes tramp's identity and goes to his home. Falls in love with tramp's childhood playmate. Tramp returns home. Club man, ousted in disgrace, elopes with girl. Pursued by girl's father. Overtaken in club man's rooms after marriage. Girl's father sees wealth and social position of club man and forgives.

SCENARIO

Cast of Characters

Club man (C M)
Tramp (T)
Girl (G)
Girl's Father (G F) as farmer
Policeman
Two servants to club man
Guests at reception
First farmer
Second farmer
Grocer
Minister
Lady, well dressed, age 40
Two or three men, well dressed
Children

Scene Sets

Club man's rooms (Studio)
Parlor (Studio)
Interior cottage bedroom (Studio)
City park (two sets)
Outside village store
Outside village cottage
Village street
Field

Synopsis

CHAPTER I. Prologue, giving the conditions under which the true action of the drama is to occur.

SCENE 1. *City park, first set.* Discovered, T reading letter.

Title: "Dear Joe: As the father of the girl who was your childhood's sweetheart, I ask you to come back home. (Sig.) Wm. Broadhurst."

(*Back to Scene 1.*) T reads letter sorrowfully, searches pockets, no money; puts letter in upper outside coat pocket with edge visible; lies on bench, sleeps.

Enter policeman, raps T on foot with club, "Move on." Exit policeman left. Exit T right.

SCENE 2. *CM room, well furnished, table, chairs, sofa; door back, door right.* Discovered, CM opening mail. Bored look. Enter servant, brings full decanter, places on table; CM looks at decanter in disgust. CM signs to servant; exit servant back, returns with coat and hat; CM dons and exits back. Exit servant back.

Title: "Seeking Food."

SCENE 3. *Same as Scene 2.* Enter slowly T right. Calls (face business). Raps on table, indicates hunger, sees decanter, makes great show of resistance to temptation, drinks and falls asleep on sofa.

SCENE 4. *Parlor.* Discovered, many guests. Enter CM. Several ladies overly attentive to CM, bores CM much. Exit CM.

SCENE 5. *Same as Scene 3.* Discovered, T asleep. Enter back CM bored. Presently discovers T, calls. Enter two servants. Servants surprised. CM sees letter in T pocket, takes letter and reads.

Title: (Repeat title showing letter in Scene *1*.)

(*Back to Scene 5.*) CM (face and stage business) forms plan for a lark. CM puts money in T pocket in place of letter. Orders servants. Exeunt servants right, carrying T. Exit CM back.

SCENE 6. *City park, second set.* Enter servants left carrying T; place T on bench. Exeunt servants left.

Title: "The Club Man Plans to Take the Tramp's Place."

SCENE 7. *Same as Scene 5.* Enter CM back dressed as tramp. Enter servants right. CM explains, servants try to dissuade but fruitlessly. Exit CM back; servants in despair.

CHAPTER II. The normal or main action of the drama.

SCENE 8. *Outside Village Store.* Discovered, grocer and first and second farmers. Enter CM as tramp. Shows letter to grocer. Grocer surprised, tells farmers, farmers surprised, all welcome CM. Grocer indicates direction, CM exit right.

SCENE 9. *Outside Village Cottage, back yard.* Discovered, GF in chair. Enter from cottage G with newspaper, show of affection, G gives paper and exit into cottage. Enter CM right, inquires of GF, introduces self, GF refuses to accept identity, CM shows letter, GF accepts identity and welcomes CM, GF calls, enter G from cottage, introduction, surprise, welcome, face business of admiration by CM, all exeunt into cottage.

Title: "Unpleasant Duty."

SCENE 10. *Same as Scene 9.* Enter from cottage GF with hoe, and CM. Exeunt right.

SCENE 11. *Field.* Enter GF and CM left. GF hands hoe, to CM and indicates work in field. CM takes off coat and begins awkwardly, GF scolds, CM works harder, exit GF left.

Title: "Pleasant Duty."

SCENE 12. *Same as Scene 11.* Discovered, CM hoeing in field. Business of weariness, lights cigarette, sits on coat. Enter G left. CM hides cigarette quickly, welcomes G. G indicates leaving together, exeunt together left.

SCENE 13. *Village Street.* CM and G pass across together, right to left.

SCENE 14. *Same as Scene 8 with children playing in extreme background.* Discovered, grocer and first and second farmers. Enter CM and G right. Exeunt into store CM and grocer and first farmer. Second farmer proposes marriage to G, indicating his wealth. Refused by G. Exit G into store. Enter from store G, grocer, first farmer and CM carrying packages. Exeunt CM and G right. Enter CM right, pays grocer, exit CM right. Stage business indicating that CM is accepted and well liked.

SCENE 15. *Same as Scene 9.* Discovered, GF in chair. Enter CM and G right, welcome by GF, exit G into cottage, exit CM right, stage business by GF indicating that CM is accepted and well liked.

CHAPTER III. The interfering action of the drama.

SCENE 16. *Same as Scene 6.* Discovered, T asleep. T wakes, remembers letter, finds paper money in pocket instead, is surprised, exit right in glee.

SCENE 17. *Same as Scene 14.* Discovered, grocer, first and second farmers. Enter T right. Recognizes grocer, grocer denies T identity, exit grocer into store. T recognizes first farmer, first farmer denies T identity, guards his watch and exit right. T recognizes second farmer, but second farmer avoids hand and eludes T, making exit into store. T alone on stage, face business of wonder and surprise. Exit T right.

SCENE 18. *Same as Scene 15.* Discovered, GF in chair. Enter T right, recognizes GF, GF denies T identity. T lip language and gesture, "I am me."

Title: "The Tramp Proves His Identity."

(*Back to Scene 18.*) T (stage business) tells of accident while swimming and diving as a boy and shows scar on head, shows birthmark on neck. GF satisfied with identification, calls to cottage, G enters from cottage, introduction, G surprised. GF angry, calls off stage right, CM enters right, shows agitation on seeing T, GF rages, GF orders CM away, G tries to follow, GF interferes, exit CM right, exeunt G, GF, and T into cottage.

SCENE 19. *Interior cottage bedroom, practical door at back opening inward with lock and key, practical window right.* Enter G and GF, GF rages, G cries, GF puts key in door on outside, exit raging and closes door. G tries door to show it locked, sinks crying by bedside.

CHAPTER IV. The resolution of the plot and the conclusion of the drama.

SCENE 20. *Same as Scene 13.* Enter CM right, walking rapidly, hesitates, shows much money, laughs, turns, exit right.

SCENE 21. *Same as Scene 19.* Discovered, G crying by bedside. Enter CM, head only at window, calls, G responds slowly, confusedly, then quickly. CM invites elopement, G consents, gets wrap, exit through window.

SCENE 22. *Same as Scene 20.* Discovered, first and second farmers approaching in extreme background. Enter CM and G right, talk, CM shows and offers money and by accident drops paper from pocket when taking money from pocket, G refuses money, embraces CM, exeunt G and CM left. Farmers reach foreground, converse excitedly. First farmer exit right. Second farmer sees paper, reads, and exit right.

SCENE 23. *Same as Scene 18.* Discovered, GF in chair. Enter first farmer right, tells GF of elopement. GF exit to cottage.

SCENE 24. *Same as Scene 21.* Enter GF by door, looks around room, notices open window, stage business of despair and rage, exit through door.

Scene 25. *Same as Scene 23.* Discovered, first farmer. Enter GF from cottage, raging. Enter second farmer with paper, shows paper to GF. GF reads. All exit right, GF raging.

Title: "The Marriage."

Scene 26. *Same as Scene 5.* Enter CM as tramp and G back. CM rings; enter two servants back; CM orders first servant; exit first servant; CM orders second servant; exit second servant. Stage business of love scene. Enter first servant and woman, stylish, age 40, apparently relative of CM, introduction to G, enter two men well dressed. Enter second servant and minister. CM explains to minister; produces paper, apparently license to wed, and hands to minister; minister reads, indicates readiness, performs marriage ceremony; congratulations by all. In midst of confusion, enter GF raging and first and second farmers. GF tries to seize G; G clings to CM; servants and guests interfere; CM tells GF they are married; G tells GF they are married; minister tells GF they are married; GF in despair and rage, farmers in despair.

Title: "Convinced of Son-In-Law's Wealth, Father Forgives."

(*Back to Scene 26 with minister talking to GF.*) Minister explains to GF that CM owns the house. GF surprised, asks servants, who answer yes; asks men, asks woman, asks CM; all answer yes. Still hesitates, gesture of appeal from G, GF takes G and CM in arms and dances. All joyous. (End of picture.)

SPECIMEN COMEDY

The requirement of a comedy is that there be a laugh at the close, and as many before that as possible. In a comedy which is neither chase nor trick, the plot should show the successive steps of story telling: first, the prologue setting forth the conditions under which the action of the story is to occur; second, the action of the story, which may be in several parts; and last the resolution and conclusion.

TITLE

The Old Maid's Dream

PLOT

Comical spinster falls asleep on park bench; nearby sits man accompanied by large dog. Spinster dreams she is being kissed. Wakes and finds dog licking her face.

SCENARIO

Cast of Characters

Spinster, burlesque in manner and attire
Man, portly and dignified
Dog, large and shaggy preferred
Parlor Maid
Several well dressed young men

Scene Sets

Park with two adjacent seats
Parlor

Synopsis

CHAPTER I. Prologue.

Scene 1. *Park with two adjacent seats.* Enter spinster right, takes nearest seat. Enter man and dog left, man takes remaining seat, spinster much disgusted. Man falls asleep. Spinster glowers and fusses but sticks to the seat and finally shows drowsiness.

Title: "The Dream."

Scene 2. *Parlor.* Discovered, spinster reading letter and smiling much. Enter parlor maid, announces caller, exit and return with first young man. Exit parlor maid. Welcome of man by spinster, man begins to kiss spinster. Enter second young man unannounced, surprise and confusion of all; exit first young man hastily in confusion. Business of love-making by second young man and spinster, young man begins to kiss spinster. Enter two more young men unannounced, surprise and confusion. Enter more young men, all give excess attention to spinster, then begin talking among themselves as if quarreling about spinster; meanwhile one young man is aside with spinster and begins kissing excessively.

Title: "The Reality."

Scene 3. *Same as Scene 1.* Discovered, man on seat asleep and spinster on other seat asleep, dog licking spinster's face. Spinster wakes, horrified, belabors dog with umbrella and then belabors man with umbrella. Exit dog and man, left.

Title: "But It Was a Lovely Dream."

(*Back to Scene 3.*) Stage business of rage by spinster looking off left, then slowly subsides, sits on seat, clasps hands, smiles and looks upward in attitude of blissful reverie. (End of Picture.)

The reviewing editor of a motion-picture manufacturing company probably would read as far as "Dog," and reject the manuscript. Trained animals are almost an impossibility in motion-picture production. It would be necessary to find an actress who possessed such a dog, or an actor who could make up as a spinster and who possessed a dog which would lick its master's face. Aside from this, there is the method of enticing the dog by food or sugar, but this is remote in probability of a successful picture.

SPECIMEN CHASE AND TRICK SCRIP

When trick pictures are written, the author must keep his tricks within the possibilities of the art. In chases, the author's scenes must be influenced by the opportunities of the producer. In the following "scrip"—as the written story of a picture before production is called—the title, plot, and scenario are given, and these should be followed by a set of trick notes by the author explaining for the benefit of the producer how the various trick scenes shall be or may be produced.

TITLE

High Jumping Johnnie

PLOT

Johnnie is an acrobat out of a job. Hungry, he buys a sandwich but has no money to pay. The sandwich man chases him. He runs into an apple cart, upsets it, and the apple man chases. Upsets stand of newsdealer, who joins chase. Upsets baby carriage, nurse joins chase. Collides with policeman, who joins chase. The chase now being on, Johnnie easily vaults a wall, which the others require ladders to climb. In a barn-yard, hay-loft door of barn is 8 feet from ground. Johnnie vaults in easily; others try, but must enter by door; when all are in, Johnnie jumps out of loft door and flees down a country road toward a bridge. Johnnie jumps from bridge into water; pursuers follow; Johnnie jumps back from water onto bridge; pursuers must climb out over the bank. In hot pursuit down country road, Johnnie jumps sheer to the sky and catches a passing airship, making final getaway. (See trick notes; practical airship not required.)

SCENARIO

Cast of Characters

High-Jumping Johnnie, an acrobat, must jump well, swim well, and have experience on the horizontal bar
Double for Johnnie, or dummy substitute
Men, first and second
Aviator, and assistants
Pursuers, including policeman, nurse, men, etc.

Scene Sets

Circus tent entrance or exterior (Studio)
Another circus tent with entrance and sign (Studio)
Cloud canvas on rollers. (See trick notes J and L)
Bedroom (Studio)
Office building entrance, with sign
City street scenes
Country scenes
Bridge and water scene

Property List

SCENE 1. Bed, table, chairs, washstand, mirror, comb, washbowl, water pitcher, towel, dumb-bells, Indian clubs, circus bill.
SCENE 2. Sign, packing box.
SCENE 4. Sign.

SCENE 5. Park seat, sandwich wagon with sandwich material complete, white apron and cap and large fork for sandwich man.
SCENE 6. Apple cart and apples.
SCENE 7. Trestles and boards to be knocked off; newspapers and magazines.
SCENE 8. Baby carriage; dummy baby; stripe uniform for nurse.
SCENE 9. Uniforms for two policemen.
SCENE 10. Trestle for jump from fence; two or three ladders, say six-foot, eight-foot and ten-foot, one each.
SCENE 14. Dummy for Johnnie if double is not available; duplicate costume for double if double is available.
SCENE 17. Airship. (See trick notes.)
SCENE 18. Horizontal bar.

Synopsis

CHAPTER I. Prologue.

SCENE 1. *Bedroom, poorly furnished; dumb-bells and Indian clubs on floor; circus bill announcing "High-Jumping Johnnie" on wall.* Discovered, Johnnie washing face. Takes short turn with clubs or dumb-bells, dresses for street, stage business toward circus bill on wall, looks at watch, exit through door.

Title: "Loses His Job."

SCENE 2. *Exterior of circus tent entrance. Sign on tent, "Closed by Sheriff."* Discovered, first man sitting on packing box near tent wall, head in hands. Enter Johnnie, sees sign, consternation at sign, taps man on shoulder, asks about sign, man shakes head. Johnnie indicates pocket and stage business of asking whether anybody gets any pay; man shakes head. Man assumes disconsolate pose again. Exit Johnnie, doleful.

SCENE 3. *Another circus tent entrance.* Enter Johnnie at one side, exit into tent; enter from tent Johnnie and second man; Johnnie is asking for employment, stage business of showing that he is an acrobat; man shakes head always indicating no work for Johnnie. Exit man into tent. Exit Johnnie one side after stage business of disappointment and hunger.

SCENE 4. *Office building entrance. Sign at door reads, "Theater Agency. Vaudeville Acts Wanted."* Enter Johnnie one side, sees sign, business of joy, exit into office building entrance; business of passers-by; enter Johnnie from office building entrance, sorrowfully. No work. Exit one side after stage business of hunger.

CHAPTER II. The Chase, in the city.

SCENE 5. *Edge of park; park seat left; red-hot sandwich man and cart at curb at right; camera set to panoram from seat to sandwich cart.* Enter Johnnie, left, disconsolate. Hunger, despondency. Looks off stage right, becomes thoughtful, rises and walks toward right. (*Panoram camera to follow actor.*) Stops at sandwich cart, talks with man, orders sandwich; man makes sandwich and hands to Johnnie; Johnnie takes bite; man asks for pay; Johnnie explains; man angry; Johnnie continues explaining; man threatens; Johnnie runs with sandwich; man follows with apron, cap, and fork; exit around convenient street corner.

SCENE 6. *City street.* Discovered, apple man and cart. Enter Johnnie running, collides with cart and falls, but holds on to sandwich; scatters apples in street. Johnnie recovers feet, picks up an apple, puts apple in one pocket and sandwich in another and runs off stage. Enter sandwich man; exit sandwich man and apple man pursuing Johnnie.

SCENE 7. *City street corner. News stand and attendant.* Enter Johnnie running, collides with news display, upsetting it but keeps on running. Enter pursuers, business with newsdealer, who joins chase. Exeunt, running.

SCENE 8. *Residence street scene.* Enter nurse with baby in carriage. Enter Johnnie running, collides with carriage, overturns carriage but keeps on running. Enter pursuers. Exeunt pursuers running, including nurse, baby, and carriage.

SCENE 9. *Street corner in residence district.* Enter left up one street two policemen. Enter right up other street Johnnie running. At corner, Johnnie collides with policemen. Exit Johnnie, running, left. Enter right pursuers running after Johnnie, talk with policemen, exeunt all running left.

SCENE 10. *City or suburban scene with wall 8 feet high.* Enter Johnnie, makes running jump sheer to top of wall (Trick Note A) and down on opposite side. Enter pursuers. Run to wall, attempt to climb but all fail. Exeunt two or three and enter again with short ladders, all scale wall and vanish on other side.

CHAPTER III. The Chase, in the country.

SCENE 11. *Country with fence and gate.* Discovered, Johnnie in background, running toward camera, clears fence by leaping from earth to top of fence and again to earth (Trick Note B), runs toward camera, and exit. Enter pursuers who at first try to climb fence but discover gate and open it, passing through gate and toward camera and exeunt in pursuit.

SCENE 12. *A steep earth bank 5 feet high.* (Note C.) Enter Johnnie on top of bank, leaps to bottom; enter pursuers, following and coming down bank; exit Johnnie on lower level; exeunt pursuers following.

SCENE 13. *Similar to Scene 11, adjacent part of same bank.* Enter Johnnie on lower level, leaps to higher level (Trick Note D) and keeps on running. Exit Johnnie. Enter pursuers, lose much time in climbing to higher level. Exeunt.

SCENE 14. *A barnyard and barn, with doors at ground level and loft door about 8 feet above ground level.* Enter Johnnie and leaps into open loft door (Trick Note E). Enter pursuers and try to make loft door but fail. Johnnie takes sandwich from pocket and takes a bite, sandwich man rages. All pursuers take lower door to barn. When all are in, Johnnie jumps from loft door and exit; pursuers appear in loft door, some falling through loft door to earth and others returning by lower door. Exeunt. (Note F.)

SCENE 15. *A country road with bridge in middle distance.* Enter from foreground Johnnie and pursuers very close behind, all running toward bridge.

SCENE 16. *Near the bridge of Scene 14. Bridge is at left; the foreground is water under and near the bridge; in the middle ground is the distant bank of the river.* Enter Johnnie, left, on bridge, closely pursued. Johnnie jumps from bridge into water, pursuers all follow. When all are in the water, Johnnie jumps sheer from the water to the bridge again (Trick Note G) and runs off bridge left; pursuers lose much time climbing out of water upon bank in middle ground and exeunt after Johnnie.

CHAPTER IV. Conclusion.

Title: "The Airship."

SCENE 17. *Open country, with airship or aëroplane on ground.* Enter aviator and assistants, right; walk to airship; examine all parts carefully; aviator takes driver's seat, assistants start propellers and exeunt; airship starts and passes off stage, right, rising. (Trick Note H.)

SCENE 18. *Country road.* Enter Johnnie and pursuers, from background, running toward camera. All notice airship (off stage) and stop running, looking up. Johnnie makes sheer leap to sky, from extreme foreground, off stage through top of picture. (Trick Note I.) Pursuers run forward and off stage, always looking upward, showing amazement and chagrin after Johnnie's leap.

Title: "Safety at Last."

SCENE 19. *Airship in flight in foreground, clouds in background.* (Note J.) Johnnie enters through bottom of picture, extreme foreground, seizes airship and climbs aboard. (Trick Note K.)

SCENE 20. (Note L.) *Near view of airship.* Discovered, Johnnie, who nearly fills the screen. Takes sandwich from pocket and apple from another and eats, with stage business downward as if to pursuers on earth below. (Note M.)

SCENE 21. *Country roadside.* Discovered, all pursuers in state of collapse, one or two showing rage and gesticulating toward sky toward Johnnie in airship. (End of picture.)

The average picture-play editor would read that "scrip" only so far as the first time he saw the word "airship," were it not that the mention of airship is coupled with the memorandum, "See Trick Note."

TRICK NOTES

Trick Note A. *The leap to top of wall and the entrance may be made in one action with reversing camera. Johnnie takes position on top of wall, back to camera; mark chalk line around both feet; start reversing camera; Johnnie stoops, puts hands on top of wall, leaps backward to earth, easing leap with hands on wall; then runs backward off stage at entrance point. When reversed in the print, this enters Johnnie and carries him to the top of the wall in a flying leap. To complete the scene, Johnnie takes same position on top of wall, feet in chalk lines, and assumes as nearly as possible same attitude; start direct camera; signal pursuers on; pursuers enter and Johnnie leaps forward from camera out of sight. A platform beyond the wall may shorten the leap, which should not have the aid of hands. The two actions, reverse and then direct, complete the scene.*

The leap to top of wall and the entrance may be made in two actions. First action: Johnnie takes position on top of wall, back to camera; mark chalk line both feet; start reversing camera; Johnnie stoops, puts hands on top of wall and leaps backward to earth, easing leap with hands on wall; mark carefully around feet and around hands if hands touch earth. Second action: Start direct camera without actors; Johnnie enters, runs to wall, and takes exact position with feet as marked in jump from wall, assuming as nearly as possible the same attitude *as when landing from the wall. Third action: The scene from top of wall, with direct camera, as before. The three actions, direct, then reverse, then direct, complete the scene.*

The leap before the reversing camera should be backward, not face toward the camera, and the effect of the hands upon the wall is that at the end of the rise they help Johnnie to gain the top with his feet and acquire a momentary equilibrium there. The scene in two actions is preferred if Johnnie is competent to run backward realistically. If the three-action method is adopted, the change from the first entrance to the reversing action may be made either at the point of leaving the ground for the leap, or a few steps prior to rising.

Trick Note B. *Same method as for Trick Note A. Mark with chalk the position of the feet upon the top of the fence. With Johnnie "jumped" into the picture, running almost directly toward the camera and on the distant side of the fence, the awkwardness of running backward will be obscured and less running backward will be required, so that the two-action method should be thoroughly feasible. In the second action, enter the pursuers before Johnnie leaves the fence jumping down.*

Note C. *One side of a railway cut ought to serve for this scene set. A water-washed gulley or river bluff with beach at bottom is suitable.*

Trick Note D. *Same method as for Trick Note A. The backward leap for safety's sake, should be squarely backward and not diagonally over the bank. Use hands as before. Mark position of feet as before. Two-action method preferred, and Johnnie may be "jumped" into the picture if desired.*

Trick Note E. *Same method as for Trick Note A. As it is desirable that the pursuers shall enter as quickly after Johnnie, the last action of the scene may start with Johnnie in crouching position in loft door with back to camera, the pursuers coming on while he rises and turns to face out of the door.*

Note F. *Scene 14 may be staged in a city house if preferred, selecting a house with high first floor, the windows being about 8 feet from the ground. Johnnie jumps into an open window, pursuers rage under window, then enter house up steps and through front door, then Johnnie jumps from window and runs.*

Trick Note G. *Scene 16 may be made according to any one of three methods, which may be named the double method, the dummy method, and the repeater method. The first is preferred if an actor for Johnnie's double is available.*

The "double" method is so named because it uses two actors who are "doubles," looking so much alike or made up so much alike that the audience does not distinguish them one from the other. As the substitute for Johnnie appears for but a brief period and is in active motion all the time, the resemblance need not be exceedingly accurate. In producing Scene 16 direct and reversing cameras are used. First action: Johnnie's double enters left, on bridge, direct camera running, and jumps from bridge into water, followed even before diving by the leaders of the pursuers, who plunge after him. Second action: When all pursuers are in the water, start reversing camera. Pursuers make much splashing but make no progress in swimming forward, but anyone skilled in swimming backward may do so. Enter the real Johnnie walking or running backward, entering left on bridge and walking backward to the point of diving, diving backward if he has sufficient skill in diving, a straight backward jump, striking the water feet first being preferred. Third action: Start direct camera. Pursuers may *swim forward now and climb out upon bank opposite camera, thence running across bridge and exeunt left. The actions are used in the scene in the order in which they are taken. In the last action Johnnie must not be seen, even though the camera must be stopped to get him out of the picture.*

The "dummy" method requires a weighted dummy resembling Johnnie. In the first action, the real Johnnie runs on left and crouches upon the edge of the bridge, simulating a leap as nearly as possible, but does not go into the water. The camera is stopped, a dummy is substituted, held by a string running off stage; start the camera, release dummy by the string and order pursuers on. The dummy is weighted to sink when it strikes the water. Second and third actions as before. Poorest of the three methods.

The "repeater" method requires Johnnie to dive twice and uses a dummy as well, but the dummy merely makes a splash and does not appear in the picture, so a weighted bag is sufficient. The first action is in two parts. Johnnie runs on left and dives from bridge; stop camera; Johnnie comes from water; dummy is fixed to bridge to be released to make splash by pull of string running off stage. Start direct camera, release dummy weight for splash, order pursuers on as water splashes. Second and third actions as before, the second action being all the better because Johnnie's clothes show wet.

Trick Note H. *Scene made in two actions, the second action being with reversing camera. Build a dummy aëroplane after the Wright biplane model, an easy type to copy in dummy. Arrange it to slide backward to earth on a pair or more of inclined wires. Must have practical propellers turning very easily by slight breeze. Make second action of scene before making first action.*

Second action: With reversing camera. Enter airship with aviator in driver's seat, sliding backward down inclined wires, propellers turning. Airship stops on ground, but propellers keep on turning; aviator takes tableau attitude to be assumed again in first action.

First action: With direct camera. Discovered, the aëroplane just as it was in tableau of second action, but without aviator and with propellers stopped. Propellers may be tied to frame with a light string easily broken. A sufficient breeze should be blowing to turn the propellers continuously after they have started. Enter aviator and assistants, or they may be "discovered" or "jumped in." Inspect airship thoroughly. Aviator takes seat; assistants start propellers by turning them forcibly which breaks string and breeze then keeps them turning. Exeunt all assistants left. Aviator in driver's seat assumes the tableau pose of the second action, made at the close of the second action in front of the reversing camera and, therefore, appearing at the beginning of the second action of the scene in reproduction.

In lieu of the dummy airship and the staged action, a bona fide airship or aëroplane making a bona fide start or a view of an airship in flight would serve the purposes of Scene 17. Stock actors need not appear in the scene. One direct action scene of a bona fide airship under any condition of motion would be all that the scene requires, the trick feature of the start of the dummy being entirely obviated.

The entire series of scenes involving the airship or aëroplane may be made with a free balloon instead, if the properties are more easily available to the producer. Scene 17 is then a bona fide scene of any balloon ascension. In Scene 18, Johnnie leaps to catch a dangling rope. Scene 19, the basket of the balloon is seen *and Johnnie enters by climbing the rope through the bottom of the picture. Scene 20 is staged in the balloon basket.*

Trick Note I. *In front of the camera and as high as Johnnie can jump and catch is a fixed horizontal bar such as acrobats use. The camera is set to take the ground below the bar as the foreground line of the picture and to clear a foot or more between the bar and the upper line of the picture, the bar being above the picture. With a bar 7 to 8 feet from the ground and with a 3-inch lens in the camera, the distance from camera to bar would be about 24 feet. The distance between standards supporting the bar must be more than 8 feet that the standards may be out of the picture. The shadow if any must fall toward the camera, that it may not show in the picture. When Johnnie leaps and catches the bar he pulls himself out of the picture as rapidly as possible, and at that time all eyes have been fixed above the horizontal bar, as though the airship were just there, and as though Johnnie has jumped and caught the airship. If he can get out of the picture quickly enough, it will seem that he has jumped higher than the picture to catch the airship.*

Trick Note J. *The airship (dummy or bona fide) is rigidly supported by invisible wires or by trestles at its ends, in the latter case the camera being set close and the trestles being off the sides of the picture. Flight is simulated by painting clouds on a canvas band and mounting the canvas on rollers and moving the clouds past the ship as a moving background. A slight panoram movement and vertical rocking movement of the camera simulates the tipping and swerving of the airship in flight.*

Trick Note K. *Johnnie enters by jumping upward and catching the airship as an acrobat catches a horizontal bar, then climbs aboard.*

Note L. *A near view of the motionless airship. If the cloud curtain on rollers is used, it may be shown as a background, Scenes 19 and 20 being combined. If roller cloud curtain be not available, the view may be so taken that no motion is needed, Johnnie and the near parts of the airship filling the screen, with possibly the aviator also visible. Use the rocking or panoram of camera to simulate the airship's movement.*

Note M. *If bona fide airship is available, no trick flights are required, all pictures being made with the airship at rest except the bona fide start, or a short bona fide view of the airship in flight. If stock negative of an airship in flight is available, it may be used for Scene 17 and the dummy for Scenes 19 and 20 may be of a design in imitation of the airship of Scene 17.*

SPECIMEN TRAVEL SCRIP

As a task for an author, the writing of a scrip for a travel picture is not a long nor a difficult task. It is at most a guidance for the producer. In many cases the author's scrip may be dispensed with altogether, the producer going into the field equipped with the camera only and making photographs of whatever opportunity may offer in the hope of piecing them together to form an acceptable series. The following scrip is a specimen which might be given to a producer as his instruction, with liberty to omit any unduly difficult scene and to add whatever scenes may be offered by chance.

THE MARRIAGE OF NAPOLEON TO MARIE LOUISE
Scene from the Vitagraph Life Portrayal of "Napoleon, the Man of Destiny"
Courtesy of the *Vitagraph Company of America*

SCENE FROM PHOTOPLAY, "BACK TO THE PRIMITIVE"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

TITLE

A Trip Across Lake Michigan

PLOT

A trip beginning in Chicago and ending in South Haven, Michigan, via steamer "Westland," showing something of fruit traffic.

SCENARIO

Cast of Characters

None

Scene Sets

None Special

Synopsis

Title: "Chicago River."

Scene 1. Panorama from one of the bridges, showing large passenger steamers at dock, showing particularly the *Westland*, on which the trip is to be made.

Scene 2. Turning of a bridge and passing through of a large freight boat.

Scene 3. Leaving of the little passenger boat on its frequent trips down the drainage canal.

Title: "Away for Vacation Days."

Scene 4. Ticket window, people buying tickets.

Scene 5. Gangplank of steamer, people going aboard.

Title: "Leaving the River."

Scene 6. Travel scene from bow of boat, showing opening of Rush Street bridge to let boat through. Better make this with trick handle, half speed. Show also points of interest on banks of river and lighthouse on pier at mouth of river.

Title: "Chicago Water Front."

Scene 7. Panorama of Chicago water front. Make this from the outer breakwater, two or three camera stands if necessary.

Title: "Out of Sight of Land."

Scene 8. Panorama of waves, showing details of boat structure, sweeping the horizon rapidly from stern of boat to stem without showing land.

Title: "South Haven, Michigan, Breakwater."

Scene 9. View from bow of steamer as vessel approaches the mouth of the river. Trick handle probably.

Title: "South Haven."

Scene 10. Panorama of South Haven water front. Make from lighthouse at end of pier.

Title: "Oh! There you are!"

Scene 11. Passengers disembarking from boat. Greetings by friends. May require some posing and stock actors.

Title: "Off for a Day on the Farm."

Scene 12. 'Bus, loaded, driving down village street, passengers waving to camera man.

Title: "Peaches."

SCENE 13. Peach orchards, picking peaches, packing in baskets, hauling to town, loading on steamer for Chicago market. Grapes, plums, anything that can be had of the fruit industry. Several scenes.

Title: "South Haven Amusements."

SCENE 14. Dance pavilion, roller coaster, the little launch on the river loaded with passengers. Several scenes. (End of picture.)

The picture-show patrons like the dramas and comedies and as a rule find the travels tiresome. They demand the dramas and make caustic remarks about the dry travels. The theater managers get this sentiment from their patrons and, in turn, take it to the film exchanges, refusing travels sometimes when offered for exhibition. The film exchanges, in turn, carry this sentiment to the manufacturers. The result is a strange dodge on the part of the film manufacturers, producing what might be called a *travel and drama* or *travel and comedy*. It is produced by combining something of a dramatic or comic nature with the scenery which is to form the subject for the travel picture.

SPECIMEN TRAVEL AND COMEDY SCRIP

The following is a specimen scrip for such a film picture:

TITLE

Sammy at Niagara Falls

PLOT

A scenic review of Niagara Falls. Sammy takes a train and arrives at the Falls. In recording Sammy's adventures at the Falls such scene sets are chosen as to *do* the falls completely

SCENARIO

Cast of Characters

Sammy, ordinary dress except a comical cap
Office help
Visitors at Falls for passers-by business

Scene Sets

Office scene
Bedroom, poorly furnished
A railway station
Another railway station, with sign, "Niagara Falls"
Natural scenery at Niagara Falls, New York

Synopsis

Title: "Sammy is Off for a Vacation."

SCENE 1. *Office, with Bookkeeper and Typewriter Operator.* Discovered, Sammy, bookkeeper, stenographer, other help. Sammy in great glee, talks to all, serially, makes more confusion than headway with his work, bookkeeper hands him pay envelope, Sammy tears open and takes out money, waves money in glee, gets hat, exit, all stopping work and waving adieu.

Title: "Where Shall I Spend My Vacation?".

SCENE 2. *Bedroom.* Enter Sammy, in glee, carrying newspaper. Takes off hat and coat, sits, feet up, reads paper with frowns, suddenly great glee, holds up paper.

Title: "Newspaper Page, showing advertisement, railway to Niagara Falls and return $4.60, tickets good one week."

(*Back to Scene 2.*) Sammy throws down paper, takes hat and coat, takes money from pocket and replaces it, exit.

SCENE 3. *Railway station platform.* Enter Sammy, paces platform impatiently; enter supes and passers-by. Enter train, Sammy gets on board, exit train.

SCENE 4. *Railway station platform, with station sign "Niagara Falls."* Enter train. Enter passengers leaving train, Sammy last, exit Sammy one side.

SCENE 5. Panorama of the Falls, from any convenient elevation, such as balcony at Windsor Hotel, Canadian side.

SCENE 6. Prospect Point. Shows American Falls and protecting railing at Prospect Point. After panorama to show scene, when scene is nearly out, enter Sammy with fish pole and begins to bait hook.

SCENE 7. The stone bridge. While panoraming the bridge, Sammy nearly gets run over by a rig while walking around in the roadway with a tin cup looking for water, stage business of thirst.

SCENE 8. Terrapin Island. View from Goat Island, showing bridge to Terrapin Island, panoraming for view. As view nears end, Sammy comes out half way across Terrapin Bridge with a string on his tin cup, lowers the cup into the water, hauls it up and gets a much satisfying drink.

SCENE 9. Maid of the Mist. Show boat at dock, and passengers including Sammy passing aboard, Falls in background.

SCENE 10. Camera on board the Maid of the Mist. Near view of the Falls. Sammy appears at rail in near foreground of camera and is deathly seasick.

SCENE 11. Cave of the Winds. Panoram for view, then pick up Sammy and panoram him half way across the bridges between Goat Island and the Cave of the Winds. He becomes afraid and turns back. Again attempts it, but again turns back, this time finally. Camera keeps him in field continuously. (End of Picture.)

Such a combination enables the film manufacturer to render his travel pictures more acceptable to that class of patron disliking the travel in its pure form. The exhibitor also has opportunity to advertise the picture in his theater front announcement either as "A Roaring Comic" or as "A Beautiful and Wonderful Nature Picture."

SPECIMEN INDUSTRIAL SCRIP

To depict an industry completely sometimes requires pictures taken in various parts of the world. "The Rubber Industry" should begin with views of the tropical rubber trees, curing the sap for shipment and loading on vessels. Then the scene shifts to the northern factory, the processes of bringing the rubber into commercial shape and the manufacture of some well known article wholly or largely composed of rubber. The picture may close with a scene showing manufactured article in use. The scenes taken inside the factory doubtless would require artificial lighting.

An industrial film well done sometimes involves scenes of great difficulty, and even trick pictures. The following specimen scrip calls for the "stop" picture.

TITLE

Raising Watermelons

PLOT

Preparing the ground and planting. Then a growing vine by stop picture. Picking, loading, hauling, loading cars, freight train in transit to city, melons on sale in city store front.

SCENARIO

Title: "Preparing the Ground."

Scene 1. (Select a scene with picturesque background, showing gate from field to highway. Take camera stand to panoram field, gate and highway, including background objects. Build permanent camera stand, that the identical position of camera may be taken from time to time.) Plowing and fertilizing in the fall.

Scene 2. From same viewpoint, a snowstorm scene.

Scene 3. From same viewpoint, a sleigh passing on the highway.

Title: "In the Spring, the Work Begins Again."

Scene 4. From same viewpoint, spring plowing.

Scene 5. Forming the hills for planting.

Scene 6. Planting the seed.

Title: "The Growing Plant."

Scene 7. Stop picture, studio. The hand planting the seed, the breaking of the plant through surface of earth, growing hourly to blossom.

Scene 8. Stop picture of field.

Scene 9. Stop picture of near view of melon.

Title: "Selecting the Ripe Fruit."

Scene 10. View of field with man working, testing melons for ripeness. As he comes near the camera, his tests are clearly seen, and the cutting of the stem and turning up of the white side is shown.

Title: "On the Way to Market."

SCENE 11. Wagon in field, loading the selected melons.

SCENE 12. Panoram loaded wagon through gate and along highway.

SCENE 13. Near shipping point, many wagons, all loaded.

SCENE 14. Loading the melons into railway cars, showing method of handling.

SCENE 15. The melon farmer gets the money at the car door from the shipper.

SCENE 16. From the caboose of a railway freight train, showing train ahead and scenery passing by, running through rural district.

SCENE 17. Same, entering large city.

SCENE 18. City store front, melons on sale. Lady enters and buys. Delivery boy puts purchased melon in basket and exit carrying. (End of Picture.)

Who is the Author. Usually, it is the producer. Surely no author is better qualified to write within the limitations of the motion-picture art than the producer. Surely no producer is better able to interpret a story than the author. In industrials, the producer may look over the situation in the capacity of author and write the scrip in memorandum form as his field notes for working with the camera. With the notes in hand, he takes the camera man and equipment and makes the various scenes which his notes show possible or desirable. In travels, comedy, or dramatic accompaniment, the field should be looked over to learn its possibilities, and no one is better qualified than an experienced producer. In current events, an experienced producer is the best judge of advantageous viewpoints. In chases, the central idea, the joke of the picture, may be sufficient information to pass from the author to the producer, the producer providing scenes to embody the thought in a picture within the limitations of the art and his immediate environment. It is in comedies and dramas that the author as such may be entirely remote from the producer. Scrips for comedy and drama may be written as short stories are written, and may be submitted to film manufacturers as short stories are submitted to magazine publishers.

THE PRODUCER

The producer is in charge of the studio, of the scene painters, of the sign writers, of the stage carpenters, of the property man, of the actors, and is nominally in charge of the camera men.

When the producer undertakes a picture, the scrip is made as complete as he desires by adding details of scenes, notes of probable location of outdoor scenes, names of actors suitable for the parts or notes on actors required to be found for the parts, as well as notes on other pictures being produced or to be produced contemporaneously with the scrip being studied. Studio stage sets and scenery required are noted and a property list is made. The titles also are noted, for title making is a part of the work quite distinct from scene making.

The producer keeps all his departments running as smoothly as possible, the motion scenes for a drama being produced this week while titles are being made for another drama for which the motion scenes were produced last week, and the stage carpenters and scene painters are at work upon studio settings and properties for still another drama for which the motion scenes will be produced in the weeks following.

The order of producing drama is: (*1*) Painting the scenery for the studio sets, for none but the simplest scene sets are used repeatedly. (*2*) Getting the properties and costumes. (*3*) Getting the actors and rehearsing and photographing the motion scenes. (*4*) Producing the motion scenes before the camera. (*5*) Inspecting the proofs of the motion scenes, retaking unsatisfactory scenes and making additional scenes which may seem desirable—sometimes, alas, only for "padding"—after the author's scenes have been reviewed. (*6*) Rewriting the scrip if necessary to fit the drama as embodied in the motion scenes. (*7*) Writing the titles finally and in detail. (*8*) Making the titles. (*9*) Adjusting lengths of titles and scenes to make the desired total picture length.

Studio Scenes. The scenery used for setting the stage differs from the scenery of the dramatic stage by the absence of color. Plain black and white and neutral tints are most desirable, for color is objectionable in that it may be misleading in tone values when photographed. The scenery required is only sufficient to fill the field of the camera. Usually when staging an interior, but two walls of a room are shown. In such a case, the third wall is not needed in the scene set, nor are flies needed for the ceiling. Wall scenery may be made in sections or panels, Fig. 2, and the sections may be set together as desired, making possible the use of the same painted work for several scene sets sufficiently different from each other. If a spectator should recognize any scene as being familiar because

Fig. 2. View of Indoor Studio, Showing Stage Setting for Indoor Scene

of prior appearance in other dramas, the first thought would be that the film then being viewed is an old one. To avoid this, striking scenes and highly special scenes, Fig. 3, are used but once. Only the more ordinary and characterless scenery may be used repeatedly. In Fig. 2, which is a good example of scenery for repeated use, five "flats," each so small that they resemble the "wings" of a dramatic stage setting and each only sufficient in height to cover the film window in the image in the camera, are shown combined for a scene

Fig. 3. View of Indoor Studio, with Stage Setting for Outdoor Scene

set. When rearranged with the door at right or at middle back, new and sufficiently different sets are produced for use in another drama, while with the addition of a flat having a window, still further combinations may be made to use the scenery to its limit before repainting.

A set of scenery flats so designed as to be papered with wall paper may be changed beyond recognition in a few minutes and at a very small expense merely by giving them a new dress of figured paper. For wall paper, the flats should have a width proper to take exactly two or more full width strips of wall paper, and the paper should be applied so that the figures will match at the edges when the flats are set together. Otherwise, the effect is ludicrous.

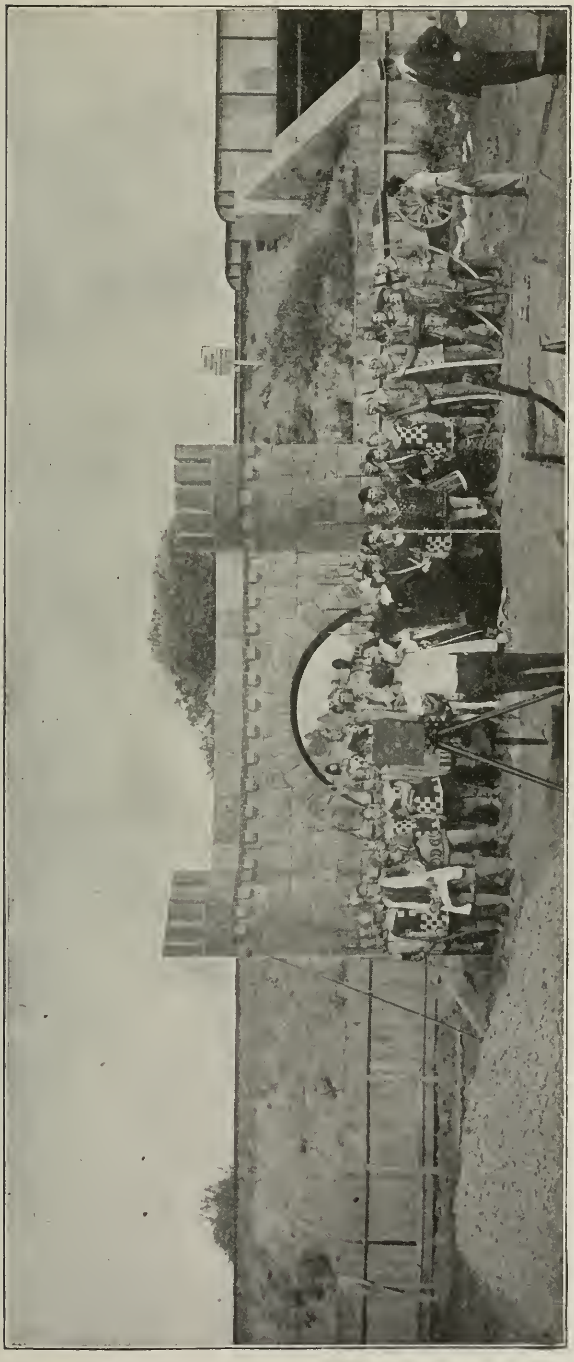


Fig. 4. View of Outdoor Studio, with Stage Setting for Outdoor Scene

In addition to painted scenery for the studio, which may represent either an interior or an exterior scene, painted scenery sometimes is used for outdoor staging. Fig. 4 shows a scene set from a production of "Richard III." made by the Vitagraph Company. The camera stands in the foreground of the illustration, facing the scene set. The field of the image in the camera does not extend to the right and left beyond the painted scenery representing the stone wall, hence in the motion picture there is given the effect of an indefinite stone wall having the arched entrance. Behind the arch is

Fig. 5. Natural Scene Setting, Outside of Cottage

a flat scene with houses and clear sky. This is a painted scene also, placed against the tight board fence which runs across the view at the foot of the railway embankment. Beyond the railway embankment are trees, the tops of which appear above the painted stone wall. In Fig. 2 and Fig. 3, the image in the camera does not extend above the top of the painted scenery; in Fig. 4 the camera includes the top of the wall and a strip of the sky above, an effect which in the studio would require a strip of sky scenery above and behind the wall. The setting of Fig. 4 is properly called a *studio set*, even though not staged inside a building. Fig. 5 shows a natural scene set.

Studio Lighting. *Artificial.* Artificial lighting for studio scenes is most economically done with mercury-vapor lamps. These lamps are made of long glass tubes containing mercury. When glowing, they give a green light, rather disagreeable to the eye at first, but very powerful in acting upon the sensitive photographic film. The light must be sufficient to impress the image upon the sensitive film in the short time allotted by the camera for each of the little pictures. This is a minimum requirement of fifty standard mercury-vapor lamps for a stage set measuring 14 feet wide, for satisfactory results

Fig. 6. Indoor Studio Setting for Outdoor Scene, Showing Lamp Arrangement for Artificial Lighting

in the finished pictures. Studio lamp plants vary from fifty to one hundred and fifty lamps, and vary in cost from $2,500 to $10,000.

As used in motion-picture studios, the mercury-vapor lamps are mounted in groups, usually six or more lamps per group, some of the lamps being hung from the ceiling of the studio for top lights and some being mounted in standing frames for side lights. The lighting arrangement will be clear from a study of Fig. 6. The studio is entirely without light other than the artificial light of the mercury-vapor lamps, which are arranged upon the ceiling and upon both sides of the scene set. In a studio of this kind, it is possible to confine all scenes to the standard stage dimensions of the studio, the lamps being properly arranged and sufficient in number to light that standard stage area properly. Working with a studio of the type illustrated in Fig. 6 makes the producer entirely independent of the weather conditions for his indoor scenes. In Figs. 2 and 3, large windows are placed in the wall of the studio at the left, making possible photography by daylight when the weather is favorable, the daylight being supplemented as desired by the artificial light. In Fig. 2, a bank of mercury-vapor lamps is suspended from the ceiling, and the side lights also are in position. In Fig. 3, a battery

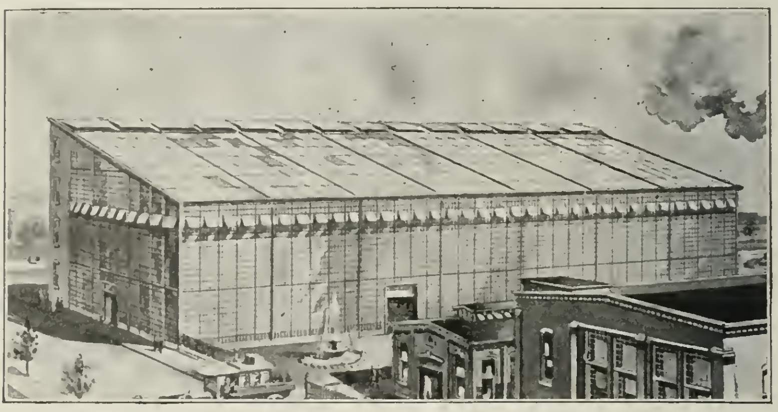


Fig. 7. Lubin Factory, Showing the Glass-Roof Studio

of top and side lights are glowing, although the daylight window is visible at the left in the view.

Daylight. There is a quality in the best daylight picture which is lacking in the best picture made by artificial light. The artificial lighting as used commercially is sufficient to impress the image upon the photographic film, but it does not reproduce in all fidelity the strength and diffusion of daylight, nor the uniformity in intensity and direction throughout the whole scene which is obtained from daylight. Lighting a large stage artificially also involves a large expense.

The daylight studio is of three types—the glass house, the turntable, and the yard. The *glass house type* of studio is shown in external view in Fig. 7. That an auxiliary lighting plant is desirable is evidenced by the details of Figs. 2 and 3.

A studio of the *turntable type* is shown in Fig. 8. The movable platform is turned to get the sunlight in the right direction. Pictures may be made with this platform from early morning until sunset, and the producer may have his light from the desired direction at all times. The exposure to rain and wind are the objectionable features of a studio of this type. It seems hardly natural for the draperies inside a house to be in motion, even in a motion picture. Unless an inside studio also is available, the producer is dependent upon the weather in more ways than sunlight alone.

The *yard studio* is a matter of setting up the scenery in a fenced enclosure, as in Fig. 4. Where the indoor studio is limited in size,

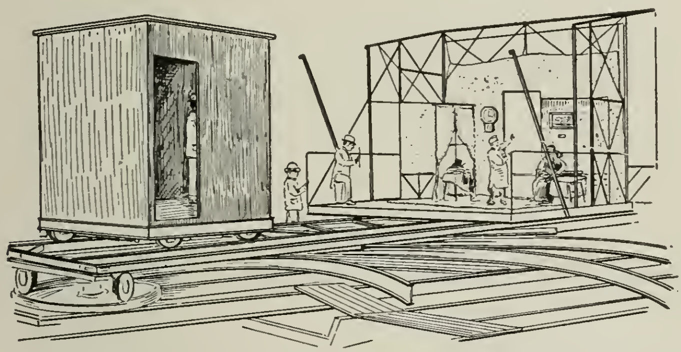


Fig. 8. The Vitagraph Roof Studio, Showing Turntable Construction

the method of Fig. 4 may be adopted for scene sets which cannot be staged in the restricted space. One adjunct usually forming a part of an established yard studio is the tank. The possibility of staging a scene with even a limited amount of water adds much to the producer's possibilities.

Pictures Without Studios. A prominent film manufacturing company operated for years without a studio and without painted scene sets, releasing a reel each week. On several occasions, film manufacturing companies, whose studios and factories are located in the northern latitudes, have sent producing companies to the tropics in the winter, where many complete dramas have been produced before the camera without studio and without artificial scenery.

The beauty and attractiveness of a motion picture is enhanced by avoiding painted scenery and its artificial appearance whenever possible. No painted scenery can equal the detail and accuracy of the physical objects. Fig. 3 would be more pleasing had the camera and actors been carried to Spain for a natural scene setting adapted to the requirements of the story.

It is the custom to stage indoor scenes in the studio with painted scenery; to stage street scenes outdoors in the streets, using the natural street scenes; and to stage rural scenes in the country. A studio set for a street scene may be made thoroughly acceptable by care in preparation of the scenery and by avoiding vegetation in the scenery. In a street scene of long duration, the studio setting is a decided advantage, since the passers-by do not have to be contended with.

The selection of natural settings is a feature of his work by which one producer easily may excel another in the quality of his product. The motion-picture camera has a "narrow angle" eye, permitting the use of a small scenic setting without including the whole country-side as a part of the view. On the contrary, by a change of lenses in the camera, just as much of the whole view as is desired may be included, panoraming the camera if necessary to include still more. The adaptability of the setting to the story is the principal point to be borne in mind when selecting natural scene settings. Pictorial merit in the scene itself is of secondary importance, but still is a matter of much importance when the best of motion pictures are desired.

In outdoor settings, whether wholly natural or wholly or partly staged with painted scenery, constant care must be taken to avoid incongruous features of the background from appearing in the picture. A scene which by the story of the drama is set in the fastnesses of a mountain range, far from any civilization, when staged in a ravine near the studio should not show a house gable in the remote distance. The scene set in Fig. 4, as viewed by the fixed camera which made the illustration, shows tree tops above the stone wall, yet the tree trunks do not appear through the arch of the wall. This would be an error if it were to appear so in the finished motion picture. The motion camera in the illustration is nearer to the scenic stone wall, thus by its different perspective and narrower lens angle placing the top of the wall higher in the sky and above the tree tops, so that the tree tops are not seen in the motion picture.

Properties and Costumes. The articles or "stage properties" used by the actors, include furniture and all kinds and classes of house furnishings from parlor clock to cook stove for indoor house scenes set in the studio; desks and typewriters for office scenes; carriages for street scenes; and revolvers and black masks for the bandits in the mountains. To obtain the articles needed for the production of a reel of film each week is a task requiring one man's attention. Once used, such articles as are likely to be used again are stored in the "property room." Unless the property man is systematic by nature, the property room soon will look like a junk shop. Costumes aside from the ordinary street dress of the actors also will be found in the property room, including particularly uniforms for policemen and messenger boys, caps and aprons for the parlor maids, and freak clothing for the comedian. The property man is the producer's assistant. Seamstresses, tailors, carpenters, and local storekeepers are in turn the assistants to the property man.

Actors. The best source for obtaining actors is the dramatic employment agency. Experienced actors are desirable, even for the minor parts, for the producer as a rule has no time for training the amateur. The custom is to employ actors for a day at a time only, the standard price being five dollars per day. One day the producer may need three or four actors, the next day twenty. In producing a drama occupying the producer for a week, he may require the leading characters for four days of work, a few minor characters for two days (one day in the studio and one day in the field) and a dozen more actors may be needed for a single scene requiring, with all rehearsals, but an hour or two.

Stock Companies. Some actors seem to have an inborn faculty for expressing thought without words, others cannot catch the trick. The producer quickly recognizes this pantomime ability in an actor employed by chance, and lists such an actor for service in the more important characters of his productions, even placing a few such actors upon a fixed weekly or monthly pay instead of employing them at the day rate with irregular service. The group of actors thus employed continuously is called a *stock company* and is supplemented by as many more actors for a day or more as may be needed for any picture. To distinguish between the stock actor and the transient, the latter is called a *supe,* an abbreviation for *supernumerary.*

Starring an Actor. For general production of pictures, continuous use of an actor in all pictures becomes objectionable to an audience. Most emphatically is this so when in two half-reel pictures the same actor takes part in the two reels The young wife who just fainted in her husband's arms at the bedside of her dead child appears on the same picture screen after a quarter-minute title as giddy sixteen flirting with half a dozen beaux. On the dramatic stage, such use of an actor is not objectionable, but motion pictures, from the fact that the scene sets are so realistic, lead the spectator to accept the actors also as real and thus add another to the burdens of the producer.

On the other hand, an actor may be "starred" in motion pictures as upon the dramatic stage. His name in the picture title will introduce him to the audience, and when his name is seen again in a title the same actor will be expected. If "Sammy at Niagara Falls" is successful on Sammy's part, the spectator will be pleased to see another title reading, "Sammy at Saratoga," "Sammy Inherits a Fortune," "Sammy Captures a Burglar," or "Sammy's First Love Affair."

Rehearsals. In the case of scenes set in the studio, it is most convenient to set the stage complete and to set the camera also in readiness. The rehearsal then is made in full dress upon the fully set stage, and when the scene is creditably performed the camera is started and the scene repeated. If the scene is difficult to reproduce, two negatives should be taken. If any flaw in the action occurs, or if the producer thinks that some variation would improve the scene, the scene should be retaken, the two scenes then being viewed and the best selected when criticising the proof copy of the film. On a scene of one minute in duration, the cost of repeating for the second negative is only two dollars for negative film, the stage set and properties being of course already at hand and the actors already rehearsed.

In the case of scenes set in natural settings, many parts of the action of the leading characters may be rehearsed before going into the field. Such rehearsals will shorten the time required in the field, and as weather conditions sometimes change suddenly, the saving of time is well worth considering.

In the street scenes where a city or village street is used, the

SCENE FROM PHOTOPLAY, "THE TEMPTRESS"
Courtesy of *Independent Moving Pictures Co., New York*

THE CONTEMPLATED SUICIDE PREVENTED BY THE BURGLARS
Scene from Photoplay, "A Good Turn"
Courtesy of *Lubin Manufacturing Company, Philadelphia*

action required should be thoroughly understood by all actors involved, and completely rehearsed if of a nature to make rehearsals possible, Fig. 9. Any rehearsal in the street will gather a crowd of onlookers, and the longer the rehearsal the larger the crowd. Even the setting up of the motion-picture camera on its tripod is in itself an invitation for a crowd to gather around it, and some of them will persist in trying to get into the view. The passing policeman usually will help, but the scenes, if any, must be short on a busy street. City ordinances usually prohibit the making of "commercial" motion

Fig. 9. An Indoor Rehearsal for an Outdoor Scene

pictures in parks or boulevards. A blind camera, in a wagon which may be stopped at the curb unobtrusively, and two or three actors fully rehearsed, may "put on" a street scene completely and have it photographed and finished before passers-by realize what is being done, or even without their knowledge at all, even utilizing some of the street traffic as a part of the scene.

Producing a Drama. To produce the drama, "A Midnight Cupid," the scrip of which has been given, the producer would classify his scenes into "studio" and "field" work, as follows:

Studio Scenes: CM room, Scenes 2, 3, 5, 7, 26. Parlor, Scene 4. Cottage bedroom, Scenes 19, 21, 24.

Field Scenes: First park set, Scene 1. Second park set, Scenes 6, 16. Store set, Scenes 8, 14, 17. Cottage set, Scenes 9, 10, 15, 18, 23, 25. Field set, Scenes 11, 12. Street set, Scenes 13, 20, 22.

Reviewing these for characters, the four principal characters and three men for minor parts will make all field work with the addition of "children playing in extreme background" in Scene 14, and Scene 6, which requires the two servants from the studio scenes; the farmers cannot double for the servants because they appear together in Scene 26.

Motion Scenes. Scene 4 requires a bunch of troublesome actresses and a large expense for wages for a single scene; if possible, it should be made when the bunch of girls are in the studio in conjunction with the scenes of another drama. By working this Scene 4 into the routine of another production having a parlor scene with the same scene set and actresses, the expense will be reduced and the producer's time will be economized.

Aside from Scene 4, all scenes should be made in continuous work. The studio being set for the club man's rooms, Scene 26 may be made first. This scene being made, the actress who played "woman aged 40" and the actor who played the "minister" is dismissed. The two "well-dressed men" may be dismissed, or they may make up promptly for grocer and policeman if the producer desires them to double in the drama. Time is allowed for them to make up for the new parts while Scenes 2, 3, 5 and 7 are being enacted before the camera with the same stage setting used for Scene 26.

Studio work for the drama now will be completed by resetting the stage for the cottage bedroom, Scenes 19, 21, and 24, the actors required being only the three leading characters, CM, G, and GF. These three scenes may be made before Scene 26, or after return to the studio from the field work, according to the producer's convenience.

The producer now takes into the field the four major actors, a policeman, two servants, two farmers, the grocer, and children for Scene 14. Scene 6 is rehearsed and performed before the camera; the two actors taking the part of servants are then dismissed. Scene 16 follows Scene 6 without permitting the tramp to rise from his position on the bench, the action of the two scenes being substantially continuous, but the camera lens being capped for a foot of the film to make a break in the negative between the two scenes when the negative is developed.

With a slight change in camera stand, Scene 1 is produced, and the actor taking the part of the policeman may be dismissed.

Proceeding to the village where the natural scene settings have been selected or are known beforehand to exist, the outside of the village store is taken first, Scenes 8, 14, and 17 being produced in order. The children now may be dismissed. The street set may be made next, making Scenes 13, 20, and 22 in order. Next the cottage set, making in order Scenes 9, 10, 15, 18, 23, and 25. Then the field set for Scenes 11 and 12 completes the action scenes of the drama. The scenes have been made in this order: 4, 26, 2, 3, 5, 7, 19, 21, 24, 6, 16, 1, 8, 14, 17, 13, 20, 22, 9, 10, 15, 18, 23, 25, 11, 12. The titles are yet to produce.

Review and Criticism. When the negatives have been developed, a print is made from each and all are spliced together in the order in which the scenes occur in the drama. The complete drama, in action scenes only, is projected for the criticism of the producer and others, including perhaps the author. The result of this criticism in some cases may be that the entire production is rejected, even the story being condemned as unsuitable for a motion-picture subject, or the producer may be required to reproduce the entire drama or certain parts of it. Perhaps some actor is judged unsuited to his part and all scenes in which he has appeared must be retaken with another actor substituted.

Padding. When making each scene, the producer had before him a schedule for the length of each scene in the drama to produce the total length required. In the review and criticism, some scenes may be cut in length and others omitted for cause. If this reduces the total length of action scenes below the required amount, scenes may be substituted to fill out, or the remaining scenes may be left a little longer than their predetermined or required lengths. This is "padding" the film. As an example of what might be done at the risk of spoiling a good film picture, "A Midnight Cupid" might open with the village cottage scene setting, girl despondent talks to father, brings paper and pen, father writes, then show title the letter which the tramp reads in Scene 1. A scene of the tramp's troubles seeking food and expressing hunger may be inserted between Scenes 1 and 2.

Between Scenes 7 and 8, scenes showing the club man en route to the country may be inserted, and between Scenes 25 and 26, scenes of all the characters en route might be added. Distinction may be drawn between a scene added to lengthen the film and a scene added for the purpose of strengthening the telling of the story, only the former being "padding."

Rewriting. The scenes and their order being determined, the producer must correct the synopsis and perhaps other parts of the scrip to fit the completed drama if any correction is necessary. Particularly in the review and criticism is the matter of titles discussed, and titles in correct and final form are determined. In the corrected synopsis, the length of each scene and of each title is noted.

Titles. The titles are made by the producer or under his direction and are given to the photographer to be done into film. The title is painted, printed, written, typewritten, or drawn, or made of movable letters arranged upon a support and removed after photographing to be rearranged for other titles. The size may be anything desired. The length of film for a title should be proportioned to the number of words in the title, being thus proportioned to the length of time which the spectator requires to read it. Two feet is enough for a single word, and a foot per word may be taken as a rule for titles longer than half a dozen words.

A sign writer who personally prefers a full arm movement would paint the titles on a sheet probably 4½ by 6 feet. A sign writer who prefers to use a small brush and a wrist movement would work on cards probably 18 inches by 24 inches. In either case, black paint on a white background may be produced as such in the finished film picture, or it may be reversed by the photographer.

A very satisfactory title is produced by setting up the words with printer's type and printing the title upon a printing press. In such a case, in order that a sharp photograph may be made, the original should be at least as large as 6 inches by 8 inches.

Where movable letters are used for titles, it is necessary only for the producer to give to the photographer a written title, or a sketch of the word arrangement desired. For titles in the nature of messages, letters, telegrams, etc., the messages may be printed with printer's script type and handed over to the photographer. Such a title probably would not be larger than 3 inches by 4 inches.

Written messages may be prepared just as the picture screen is to show them, written by hand with black ink upon white paper. The handwriting of the message should be consistent with the character of the actor writing it, and should show creases if the message has been folded in the motion scenes of the play. For telegrams, use the regulation telegraph blank. Use a "send" blank for messages to be sent and a "received" blank for messages received. They may be written either by hand or typewriter.

Borders for titles or trademarks for titles may be incorporated into the titles by drawing or printing the title upon sheets which have been printed previously with the border or trademark.

A "reversed title" is a name given to titles having the letters show in white upon a dark picture screen. This effect is obtained directly by painting with white upon a black background, or by arranging movable white letters upon a black table, but it may be produced from black letters upon a white ground by an additional process in photographing. It is not suitable of course for messages. A reversed title is much more easily read and is much more acceptable to the audience than a title which has black letters upon a white ground. The reversed title is further improved by tinting.

Final Criticism. The titles being completed, and added or changed scenes having been reproduced, the proof for the first criticism has each scene cut to its prescribed length and proofs of the titles are cut to their prescribed length and inserted among the motion scenes in the order required by the revised synopsis. Thus, there is produced a final proof picture of the complete film as it is to be released to the public. The final proof is projected before the producer and critics and if approved it is turned over to the photographer as "copy." The photographer cuts his negative into lengths, both motion scenes and titles, splicing them together to reproduce a complete continuous negative of the approved "copy."

Whether the film be drama, comedy, travel, chase, or trick, the procedure of motion-scene production, first criticism, rewriting scrip, making titles, final proof, and approval of copy is on final criticism in substance the same.

At this point, the film picture passes out of the hands of the producer and into the hands of the salesman, or advertising manager of the producing company.

THE SALESMAN

The salesman of the film manufacturing company, or the advertising manager, as his title usually reads, has as his task the disposition of as many copies of the finished picture (as many photographic prints from the negative) as his opportunity and ability can effect.

Branches of the Film Industry. The customer of the film manufacturer is the film exchange manager, or renter, whose customer in turn is the film exhibitor. The film industry is definitely separated into three branches: *manufacturer*, *renter*, and *exhibitor.* The renter owns the picture films. He buys from the manufacturer for cash and rents the films to the owners of picture theaters for exhibition. The exhibitor owns no films, merely renting them for a day or a week from the renter; the manufacturer owns no positive picture films, merely printing from his film negatives as many copies of each picture as can be disposed of immediately to his customers, the film renters.

Selling Methods. General publicity is obtained among the renters and exhibitors by advertising in the motion-picture magazines. In the magazine advertisements, the general excellence of the manufacturer's film pictures is told, and the current film pictures just produced or about to be produced are announced by title with a few descriptive words and illustrations.

Lectures. The magazine advertising is supplemented by lectures or short stories of the film pictures. The lectures derive their name from the original purpose, which was to provide a talk to accompany the picture, explaining the story of the picture as the action progressed on the screen. While the original purpose of lectures is almost extinct, their advertising value remains and they are used by manufacturers in large quantities. Each film picture has its lecture and these are printed either separately or in a little pamphlet covering the manufacturer's output of film pictures for the week or for two weeks.

The lectures are written by the salesman or his assistants, using the corrected synopsis or scrip of the story as a guide and keeping in mind at all times the film as actually produced. At least the motion scenes of the picture should be produced and reviewed by the critics before the film is advertised for release and before the lecture is written. The writer of the lecture, having sat at the projection of the proofs for the preliminary review, will be further guided in writing the lecture by his recollection of the strongest scenes of the production. The lecture is illustrated by views of the film taken from the scenes either by clipping a small image from a copy of the proof film or by photographing the scene with a hand camera upon a larger scale while the picture is being produced. In either case, the engraver is able to produce printing blocks of the desired size for the lecture.

Lectures are mailed in advance of the release date of the film. They are sent to the magazine publishers that they may be printed in the magazines either in full or in part, for additional advertising value to the manufacturer. They are sent to the film exchanges that the renters may know what pictures are promised for the advance dates. They are sent to the exhibitors that the exhibitors may be impressed by the lecture that the film is especially suited to their particular audiences and that the exhibitors may ask the renters for the picture and the renter thus be obliged to buy the film from the manufacturer.

Release Dates. The routine of manufacturing and selling motion-picture films can be compared very closely with the routine of printing and selling a newspaper or magazine.

The amusement business is established upon a weekly basis. In theatrical circles, a year is spoken of as fifty-two weeks, and a day one-seventh of a week. The big theaters change their bills at the end of the week, and the vaudeville programs are changed weekly Similarly, in the motion-picture theater, the program is made upon a weekly basis, the film renter makes his schedules upon a weekly basis, and it best suits his convenience to receive his films from the manufacturers upon a weekly schedule. As the business man gets his newspaper every morning, so the prominent "daily change" motion-picture theater gets its new film every morning from the renter, who, in turn, gets films every morning from the various manufacturers. Orders are placed by the renter on a basis of weekly deliveries, that his schedule may run smoothly. Monday morning brings a reel from manufacturer *A*, Tuesday a reel from *B*, Wednesday a reel from *C*, Thursday another reel from *A*, Friday another reel from *B*, and Saturday a reel each from *D* and *E*. These deliveries are repeated weekly, giving a constant schedule of seven reels per week, combining the product of several manufacturers.

In view of the deliveries required by his customer, the renter, the manufacturer is obliged to issue his pictures as regularly and as punctually as a publisher issues his magazine to the newsdealer. Each film manufacturer, therefore, establishes one or more release days for each week, according to the number of reels of film which he will manufacture per week, and advertises that a full reel of film will be sold or "released" upon each of his release days.

Advance Shipments. It has been found convenient to release a picture in all parts of the United States upon its release date, and this is accomplished by advance shipments to discount the time in transit, and by shipments further advanced to discount the likely delays in transit. A New York manufacturer will ship his pictures to San Francisco customers seven days in advance of his release date; to Denver or New Orleans customers five days in advance of his release date; to his Chicago and St. Louis customers three days in advance; to Philadelphia and Boston customers two days in advance; and will deliver by messenger to New York customers on the evening before the date of release. In the case of the distant shipments, the films should arrive two or three days ahead of the release date, but the renter is honor bound to issue them to the exhibitor only on and after the release date. In case it comes to the attention of any manufacturer that any renter is violating the release date, the advance shipment for discounting delays in transit will be withheld.

Factory Schedule. A safe schedule for insuring the release of the picture film to the renter promptly upon the release date carries the beginning of the work of making the film back to a date many weeks before release. A picture to be released on May 6, if manufactured in New York, must be shipped to the San Francisco and Los Angeles customers a week in advance, on April 29. The photographer must have time in advance of this to enable him to print the pictures from the negative, so the approved "copy" of the film must be delivered to the photographer on April 22, two weeks in advance of release date, that he may fit his negative to the "copy" and begin printing in time for the west coast shipment. Inasmuch as the final criticism may require changes before the "copy" is approved, the projection of the picture for final criticism is set for April 15, three weeks in advance of release date. Between projection of the motion scenes for preliminary criticism and projection for final criticism, one week is not sufficient for remaking condemned scenes, producing padding scenes, rewriting the scrip and making the titles. Particularly in view of the possibility that the entire picture may be rejected, an interval of three weeks is none too short between preliminary review and final review in the ordinary progress of the factory. The date for preliminary criticism is set for six weeks in advance of release, or March 25 for preliminary criticism for the May 6 release. For ordinary productions, give the producer a latitude of two weeks for his motion scenes, and two weeks preceding for preparation of his scenery and properties, taking the delivery of the scrip to the producer back to ten weeks in advance of release date, or February 25, for the release of May 6. Still back of this date is the writing, criticism, and acceptance of the original scrip. Some pictures, particularly trick pictures, may require many weeks for the production of the motion scenes.

In contrast with this is the story told of an eastern factory, that an actor in the noon hour suggested to the producer a thought for a comedy, that the producer dropped the work in hand and had the first scene of the new comedy on at two o'clock the same afternoon, and scenes were completed for a full comedy reel the following day. In contrast also is the method of a producer who habitually worked without scrip or scenario, producing only his own creations, direct from brain to film.

Sales Contracts. The usual order accepted by the manufacturer from the renter is an order for a predetermined number of reels per week—usually one copy of each picture produced by the factory. Such an order gives the manufacturer advance knowledge of the quantity of his output and it is by such orders only that a manufacturer is enabled to work upon so close a schedule as the one cited—giving but two weeks between the final approval of the "copy" of the picture to the release date. If it becomes necessary for the salesman to exhibit an advance copy of the finished picture as a means for getting orders for the films, several additional weeks must be inserted in the schedule between the final approval of the "copy" and the date of the release of the film.

Title Posters. To advertise his program to the passers-by, the theater manager—or "exhibitor," as he is known in the trade—displays the titles of his pictures in front of his entrance. The salesman for the film manufacturer provides for attractive posters for the films released, either by furnishing them to the exhibitor directly through the film exchange to whom the salesman sells the film, or by providing necessary information to title poster companies to enable them to offer attractive title posters to the exhibitor.

REPRODUCTION

THE PHOTOGRAPHER

If the *factory* is to be considered as distinct from the *studio*, and from the *office*, then the office is the department of the salesman, the studio is the department of the producer, and the factory is the department of the photographer. "Factory superintendent" perhaps would be a suitable title for this photographer, for he does but little of the photographic work with his own hands. The divisions of his factory taken in the order in which they become useful in the making of a picture film, are as follows:

Divisions of the Photographic Factory. The raw sensitive film is purchased cut to size and packed in tin cans. A fireproof iron safe or a fireproof vault for film storage holds the film until needed. From the vault, it is taken to the perforating room, where holes are punched in the edges Thence the negative film goes to the camera man, who is the photographer's employe working under orders of the producer. From the camera man the exposed film goes to the developing room, where it is developed into a negative. Then titles are made. Scenes and titles being finally approved and spliced up according to "copy," the film negative goes to the printing room and supplies of positive film also go from the perforating room to the printing room, where the positive film is printed from the negative. The negative, after all prints are made, goes to the film storage room permanently. The printed positive film goes from the printing room to the developing room which developed the negative, then to the washing room, then to the drying room, and when dry to the inspection and splicing room and again to the fireproof storage vault until the day for packing and shipment. In brief, the divisions of the photographer's factory are film storage, perforating, camera, developing, title making, printing, washing, drying, inspecting, and shipping. The strip film is bought ready for perforating.

The total task of the photographer—or "factory superintendent" or whatsoever title he may bear in various film manufacturing plants—is to produce a creditable photographic film picture when the producer has enacted the scenes and has written the titles. This task requires the photographer to have his assistant, the camera man, present when the producer enacts a scene, and leaves the responsibility upon the photographer—through his assistant, the camera man—for the proper photographic record of the scene upon the negative film of the camera. The division of responsibility at this point is logical. If a negative is lost because the camera man used the wrong stop in the lens, the failure is photographic in nature, and the photographer is to blame because of the incompetency of his assistant. From this point to the delivery of the film for shipment, the processes are wholly photographic. The photographer assigns his camera men to the producer as demanded, providing them with negative film, and delivers proof prints to the producer for criticism. From approved proofs and picture "copy," the photographer prints finished film pictures as requested, and delivers them by shipping them under the salesman's orders.

Raw Film. *Composition.* The sensitive film before use in the camera consists of a long narrow strip of celluloid coated with a gelatine photographic emulsion. Its manufacture is distinctly in two parts, the making of the celluloid strip and the making of the sensitive emulsion and coating the celluloid strip with the emulsion. Neither the making of the celluloid nor the coating should be attempted except by skilled workmen in a thoroughly equipped factory.

Manufacture. Celluloid is made from pyroxylin and camphor, the pyroxylin or guncotton being made from raw cotton by treating it with nitric and sulphuric acids. Sulphuric and nitric acids are mixed in practically equal quantities, the raw cotton is dipped until saturated but not allowed to dissolve, then is thoroughly washed and dried. By this process the cotton has been transformed into guncotton, an article very explosive in nature, but not different in appearance from the original raw cotton. The camphor is dissolved in alcohol, making a saturated solution.

A layer of dry pyroxylin is placed in a tank and about one-half the quantity of camphor solution is sprinkled over it, then pyroxylin, then camphor, and so on. The pyroxylin dissolves in the camphor solution and celluloid is formed in lumps which sink to the bottom of the tank. The lumps of celluloid are worked between rollers, cold and hot, and pressed in hydraulic presses and dried.

The celluloid stock is worked into thin strips for motion-picture work, the strips being 1/200 of an inch in thickness. The width and length may be anything desired, say 22 inches wide by 200 feet long.

Coating. The emulsion for coating the film is of two kinds, slow for prints and fast for negatives, a bromide emulsion for the slow and a nitrate emulsion for the fast. The emulsion, made as for photographic dry plates or hand-camera films, is placed in a coating machine having an emulsion hopper and a slit to feed the emulsion upon the celluloid. The 22-inch strip of celluloid is passed at a uniform speed through the machine and under the emulsion slit, receiving a uniform coating as the emulsion flows out upon it. The wide strip of film is dried and taken through a cutting machine which splits it into strips 1⅜ inches wide and 200 feet long. The narrow strips are rolled up and packed in round flat tin cans, sealed with adhesive tape, one strip, or 200 feet of film, in each can. It is now ready for delivery to the motion-picture manufacturer

Non-Inflammable. The celluloid base of the motion-picture film is highly inflammable, although not explosive in that it will not take fire unless a flame is applied to it or it is heated to a very high temperature to start combustion. The heat of the projecting arc concentrated upon the film in the film window of the projecting machine is sufficient to ignite it. When ignited, it burns rapidly

Many experiments have been made either to discover a substitute for the inflammable celluloid for use in motion-picture work, or to discover some modification of the process of making celluloid which would render it less combustible. By adding amyl silicate or methyl silicate to the vat in which the pyroxylin and camphor are combined, a sufficient quantity of silica may be added to the celluloid to reduce its inflammability so that it will burn very slowly, if at all. The addition of calcium chloride to the celluloid compound also produces a similar result. The finished mass of new celluloid while still soft may be treated with stannous chloride, rendering it less easily combustible.

A non-inflammable product made by combining camphor with an acetate cellulose instead of with a nitrate cellulose, or pyroxylin, has been used widely as a substitute for the inflammable celluloid strip for motion films. This is the "N. I." commercial film, and gives satisfactory service for a short life. Its objectionable point is that with age and the heat of the projecting arc it shrinks to some extent and becomes somewhat brittle.

Fig. 10. Specimen of Positive Film

Storage of Film. The greatest care must be taken in selecting a place for the storage of the raw film, as also for the storage of the finished pictures before shipment, and for the storage of the film negatives, the most valuable of all, particularly during the period between preliminary approval and the release of the picture. The storage room must be so situated and constructed that the film will be kept safe from flames and will be kept cool. When warm, celluloid gives off explosive gases rapidly. A vent pipe for such gases may be formed by a pipe of small size leading to the open air and guarded with steel wool or gauze to prevent backfiring.

Perforation of Film. The standard perforation is four holes per picture, or rather four pairs of holes per picture. Each hole is approximately $\frac{1}{16}$ inch by $\frac{3}{32}$ inch, spaced along the edges of the strip of film at a distance of $\frac{3}{16}$ inch apart, making four holes on each edge for each $\frac{3}{4}$-inch motion-picture image. The photographic images being 1 inch wide, and the film strip $1\frac{3}{8}$ inch, the pictures being also in the middle of the strip, there remains a margin of $\frac{3}{16}$ inch on each side of the strip for the feed holes. The perforations are placed in this margin, not centrally in the margin, but against the side of the image to leave as wide an edge of celluloid outside of the perforations as possible to strengthen them against breaking out to the edge. In the illustration of a specimen of picture film, Figs. 10 and 11, the perforations seem to encroach upon the photographic images. Indeed, in the projected picture upon the screen, the edges of the perforations sometimes are seen at the side of the picture because of a lack of proper centering of the film in the projecting machine.

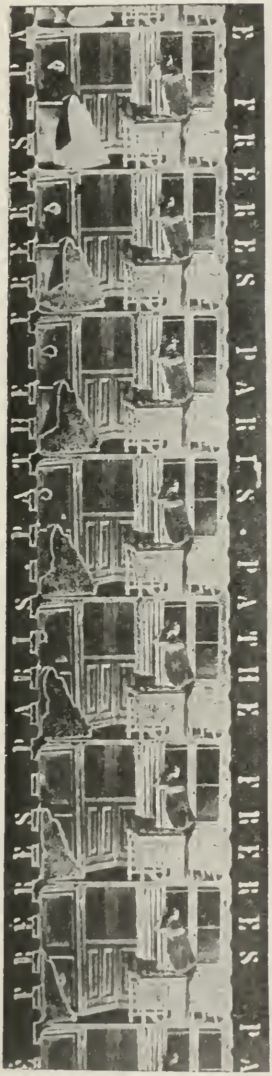


Fig. 11. Negative Film. Motion is shown by positions of lady with black skirt and white apron. (Film shows reverse colors.)

Shape. The three shapes of perforation commonly used are known as *round, square,* and *barrel.* They are illustrated in Fig. 12. The square and barrel holes seem to give longer life to the film than the hole having the round form. The shape of the tooth in the projecting machine which enters the film perforation and by which the film is pulled through the projecting machine should determine the shape of the hole. The tooth most commonly met has a flat pulling face, and this pulls best against the flat surface edge of the hole offered by the shape of the square or barrel perforation.

Spacing. The sprocket method of feeding the film allows some latitude in distance of perforations, and thus cares for slight inaccuracies in the perforating machines, and for the variation due to shrinkage of the film with age or with its treatment in the processes of development and drying after leaving the perforator. The spacing in the perforating machine should be $\frac{3}{16}$ inch per hole, and it should be uniform. Careful experiment has shown that the films whose sprocket holes wear best are those whose sprocket holes are most uniformly punched, regardless of whether they have maintained their original distances or have been subjected to change by development processes or by age. If the holes are not uniform, one hole edge will get more than its share of pull from the sprocket teeth, and that hole will break out, its neighbors then getting an excess strain and breaking in turn until the film must be cut and spliced. The splice in passing through the film gate places an abnormal strain upon the edges of the perforations in advance of it and

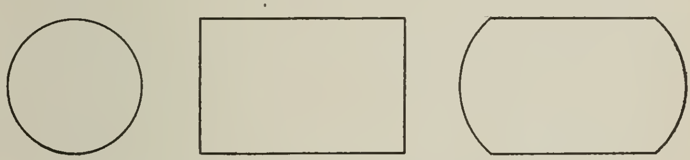


Fig. 12. Shapes of Film Perforations

which have to pull it through the gate. Thus the trouble started by uneven punching is cumulative and shortens the life of the film.

Perforating Machines. Self-feeding or automatic punch presses for punching small blanks out of sheet metal may be seen in large machine shops. When provided with proper punches and dies they become suitable for perforating motion-picture film. When the punches are of the *reciprocating* type, a group of eight punches work vertically above a plate having holes to receive the punches and having guides for the unperforated strip of film. Associated with the punches are two "pilots," tapered fingers, which come down with the punches and pass into the last holes of the film strip, that the distance from the last holes to the new holes about to be punched may be exact. An intermittent feed device, similar to that of the camera or projecting machine, works into the holes of the perforated end of the film and pulls it forward one picture length between the strokes of the punch. Punches of this type may be operated at speeds of 500 to 1,000 feet of film per hour. Only one strip at a time is punched.

In the case of *rotary* punches, two drums are built, one of which has in its face recesses corresponding to the holes of the finished film and the other of which has teeth to match the recesses of the first drum. The teeth are of such length that they reach to the edge of the recesses of the companion drum but do not enter. The drums are revolved in unison and the film strip is passed between them. Revolving brushes keep the punched-out pieces from following around the drums and entering again. Rotary punches are of high capacity, being able to perforate film at a rate of 5,000 feet or more per hour. They are more likely to get out of accurate adjustment than the reciprocating punch, and are more difficult to sharpen when dulled by service.

Perforating Room. The perforating room is a darkroom, photographically dark while the perforating machines are working the film. It is only when all film is safely shut in the tin cans that the white light may be turned on or the door opened. It has a "light-trap" entrance, or in the wall is built a turntable with four wings, like the revolving doors of a store or office building, encased light tight, with a window into the turntable inside the darkroom and another outside. By this turntable, a few cans of punched film may be passed out on demand without waiting for the punching machines to finish their strips of film to permit the door to be opened.

Camera Man. Only a photographer who has demonstrated his ability to make good negatives with the fixed camera under varying conditions should attempt to qualify for the position of camera man with a motion-picture factory. Upon the camera man, as representative of the factory photographer, rests the responsibility for getting a good negative of the scene enacted by the producer. A photographer who can make a good fixed camera negative of the scene setting can acquire easily the necessary skill in turning the camera crank at a uniform rate of speed, and then is fully competent to make a thousand motion-picture images of the same scene while the action of the scene is taking place.

Camera. The professional motion-picture camera should have the following features: A *well-balanced intermittent movement,* turning smoothly and uniformly in all crank positions; an *adjustable shutter,* adjustable to give a variable ratio between the "open time" and "closed time" of the film window for each revolution of the shutter, that is, for each picture made upon the film strip; *two or*

THE SLAVE AND HIS SWEETHEART EXCHANGE SIGNALS
Scene from Pathé film, "The Slaves' Revolt"
Courtesy of *Pathé Frères, New York and Paris*

SCENE FROM "CUPID'S CONQUEST," BY GAUMONT
A Colored Fantasy of Unusual Richness in Staging and Originality of Plot
Courtesy of the *Kleine Optical Co., Chicago*

more lenses fitting into the same mount or flange ring, the lenses being of different focal length for changing the angle of the view or the size of the images in the film window and for decreasing or increasing the depth of the field for action in the scene; *focusing mount for the lenses,* either having each of the lenses in its own focusing mount or preferably having a single focusing mount into which any one of the different lenses may be inserted; a *sliding lens board,* equivalent to the rising and falling front of the fixed camera; *detachable light-tight film boxes,* equivalent to the dark slides of the fixed camera preferably of such construction that the film boxes may be interchanged without opening the mechanism compartment of the camera; a *trick picture crank;* a *reversing crank* or a *reversing tripod socket;* a *detachable main crank* or preferably a *folding main crank;* a *level;* a *finder for panoraming;* a *finder for focusing window,* for focusing without opening the camera; an *indicator* showing the amount of film used and unused at any instant; a *speed indicator* showing at any instant the speed (in pictures per second) at which the camera is being turned; a *film marker* which may be operated from the outside of the camera to mark upon the film an indication of the position of the film window upon the film; a *stiff tripod with panoram head;* a *carrying case.* In addition to providing for the panoraming movement or horizontal swinging movement of the camera upon the tripod, the tripod head sometimes provides for a rocking movement of the camera vertically.

In size, motion-picture cameras vary greatly, even when built to carry the standard size film, $1\frac{3}{8}$ inches wide, and the standard quantity of a 200-foot reel. The comparative size of camera and man is seen in several of the figures. The Urban camera is about 18 by 18 by 6 inches. Others have been made showing a front 6 by 10 and a depth of 14 inches. Some cameras, as the Urban, carry the film boxes inside the camera case, while others attach the film boxes to the outside of the case, thus making the size of the camera case alone seem deceptive when given in figures. The weight of a camera will vary from eight to twenty pounds.

Film Movement. Successful cameras have been built by constructing a light-tight box for the motion head of a projecting machine. Such an arrangement fills all requirements although it may make a bulky camera. The limitations in building a film shift for a camera are less rigid than those placed upon the projecting machine, because of the shorter period of rest. In the projecting machine, the film must be at rest for at least eighty per cent of the time, and must be shifted in the remaining twenty per cent of the picture interval. In the camera, the intermittent mechanism may be such as to use forty per cent of the picture interval in movement if desired.

The margin of safety for a good picture in a camera is of greater importance than in a projecting machine. If the projecting machine is out of order, it is known immediately by the result upon the screen, and the machine is adjusted. If the camera is in any way out of order, it is known only when the films are developed at the end of the day's work, with the result that the day's work must be done over by the producer.

The film in the camera must be motionless during the interval of exposure to the lens. The claw type of intermittent movement seems well adapted to this end, since the claws may advance into the perforations, seize and pull down the film and retire from the perforations entirely, leaving the film entirely out of contact with the film shifting mechanism and, therefore, to the greatest degree unaffected by the driving devices which, were there any actual contact between the driving devices and film, might cause a slight movement. During the period of rest of the film the claws return to the position from which they advance into the perforations to give the film its next step, and during this interval the exposure of the film to the lens is made. That the claw-shift mechanism subjects the film to greater wear than the sprocket movement becomes of less importance in the camera than in the projecting machine, since the film is run through the camera but once.

In addition to the Edison camera, using the sprocket with perforated film strip, and the Urban, Gaumont, and many others using the claw movement with perforated film strip, all of which use intermittent movement of the film, there are two other classes of cameras—those which do not use the intermittent film movement and those which do not use the perforated film. The object in the use of cameras avoiding the perforated film and the intermittent movement usually is found in an intent to avoid patents bearing upon those features. The Bianchi camera, used by Columbia licensees, makes pictures upon a continuously moving film. The

Hamacek camera uses an unperforated film, the film being perforated after development of the negative.

Loading Film Holders. Each film holder consists of a black box of thin wood with door and spindle. One side of the box opens as a door, either hinged or entirely removable. The spindle or hub passes through both sides of the box, back and door, turning in journal boxes carried by the back and the door, and usually being removable from the box merely by lifting out when the door is open. The hub has a clip or slot for attaching the end of the film, so that the film may be wound upon the hub when the hub is turned. Upon the end of the hub—usually upon that end which projects through the back of the film holder, but in the case of the removable hub the two ends should be alike—is a key way whereby the film movement of the camera may engage the hub and turn it to wind up the film. The key is a slot or a pair of holes for pins, and in the camera at the position for the take-up film holder is a key corresponding to the key way.

The negative film will be supplied from the factory storage vault in rolls of 200 feet, perforated, rolled with an open center a little larger than the hub of the film box of the camera, and packed in a round, flat tin can sealed with adhesive tape. In loading an empty film holder, it is necessary only to open the door of the holder, open the tin box (in the darkroom), drop the roll of film over the spindle, pass the end of the film through the slot of the holder, and close the holder.

In reloading a film holder containing exposed film, the processes are different, depending upon whether the holder has a removable spindle or hub, and whether an extra hub is at hand for reloading the removable hub type of box. When the removable hub type of film holder is used, the factory should provide an extra hub with each roll of negative film, packing it in the tin box in the hollow center of the film roll. To reload, the camera man opens (in the darkroom) both tin film box and camera film holder, removes the new film from the box, lifts the exposed film from the camera film box to the tin box without removing the hub, upon which the film is wound tightly, and seals the tin box with the adhesive tape. He then fits the new hub to the film holder, drops the new roll of film over it, threads the end of the film through the slot, and closes the film holder.

In reloading the film holder in which the hub is not removable, the camera man must have a film winder, winding the film out of the holder, then changing the new roll of film from the tin box to the film holder, and then the exposed film from the winder to the tin box.

Exposed and Unexposed Films. Safeguards are necessary to avoid the accidental exposure of the same film twice in the camera, either from the mistake of putting an exposed film holder back in the camera or from the mistake of reloading an exposed film from its tin box back into the film holder and thence to the camera. In short, there should be some signal to indicate that the roll of film has been exposed, similar to the turning of the dark slide of a plate-holder.

The outside end of an unexposed roll should have its corners clipped to facilitate threading through the camera when loading. The inner end should be left square. A roll with the outer end square, therefore, is an exposed roll.

When the film holder is loaded, the leading end of the film is threaded through the slot of the holder, and projects to be pulled out and threaded up in the camera. When the roll is exposed, it is wound up completely into the take-up holder, so that the end of the film does not extend from the exposed holder.

In a camera having holders with removable spindles or hubs, the exposed roll of film will have a hub in its center upon which the film is tightly wound. The unexposed film will have the hub in the tin box, perhaps, but the film will not be tight upon it.

In a camera without removable spindles, a roll of film which has been removed by the camera man in reloading, probably will have a different size of center hole from the roll received from the factory film storage room.

Tin boxes containing unexposed negative film in the factory storage room should be wrapped in paper and the wrapper pasted shut so that the paper must be torn to get it off. When reloading film holders, the camera man does not wrap the tin cans of exposed film, hence the only fresh film the camera man has is the film in the wrapped boxes and in the film holders with the leading end sticking out.

In addition to all other precautions, the exposed film should be sent in to the factory as soon as exposed, but even then the factory may send back an exposed roll to the camera man, and danger signals should be watched for.

For studio work and field work close to the factory, film holders may be loaded in the factory darkroom. Where the camera man is in a distant city or still worse in the country, it may be necessary to transfer film from tin cans to camera film holders when no darkroom is available. A bedroom closet will serve if an assistant outside will hang clothing or bed clothing over the cracks of the door until the camera man inside can see no light. Kneeling on the floor at the bedside with the hands (and films and boxes) under the covers, either at night or with shades drawn and a bed cover hung over the window, the camera man may work by touch. Have an empty tin can and as a first operation transfer the film to the can and as a second operation transfer the film from a new can to the film holder. In the field, if the emergency arise, take off the coat and shove the arms through the sleeves the wrong way, changing the film inside the coat. An assistant supplies the film and boxes to the hands inside the coat, and muffles it further by any available clothing. Get in the deepest shadow available. For all these emergency methods it may be borne in mind that the roll of film is largely self-protecting. On the sides of the roll, the light must penetrate 3/16 inch before reaching the latent images, the inner layers are light-struck by the acts of loading the camera and they serve to protect the following layers, while on the outer layers there may be left several layers of unused film for protection if the emergency reloading is known in advance.

Loading the Camera. The loading of the camera is an operation designed for daylight work. It is no more difficult than threading a film through a projecting machine. The full take-up film holder is removed. The empty film holder is taken from the feed position and fastened securely in the take-up position, the hub being connected with the mechanism of the camera, and the handle given a few turns to ascertain that the hub is turning properly to take up the exposed film. A loaded filmholder then is placed in the feed position and the end of the film pulled out to reach the feed mechanism. A brush should be attached to the inside of the camera door by a spring clip, and the inside of the camera, particularly the film window, should be brushed carefully to remove minute particles of celluloid or other dust particles left by the previous roll of film in passing through the machine. The new film then is passed through the upper steady feed, through the intermittent feed, and through the lower steady feed, to the take-up film holder, passed through the slot of the holder and attached to the take-up hub. The take-up holder is closed, and the handle is given a turn to make sure that the film is feeding properly and that the take-up holder is working properly. The camera case then is closed and the handle is turned once or twice as required to wind past the film window that length of film between the feed film box and the film window which has been light-struck by exposure during the loading of the camera.

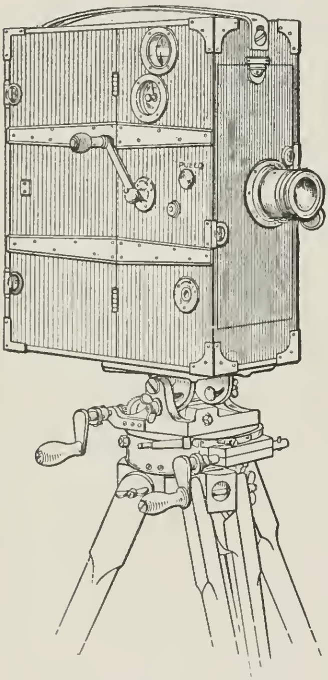


Fig. 13. Urban Camera

In Fig. 13 is shown the Urban camera, with panoraming and elevating or rocking tripod head. The door at the left on the side gives access to the film holders and feeds for reloading the camera; the removable panel in front gives access to the intermittent mechanism. Fig. 14 shows the Gaumont camera, open. In this camera the upper and lower constant feeds are taken from the same sprocket, the intermittent feed mechanism being enclosed in a dust-proof box at the front of the camera. The feed and take-up reels are external to the camera body and have a very large capacity, 500 feet.

Camera Man's Duties. *Taking the Picture.* To set up his camera when instructed by the producer, to include the scene pointed out by the producer, to begin turning and to stop turning when told by the producer, to keep his camera in adjustment, to keep an ample supply of film for the producer's requirements, and to turn over to the factory a correctly exposed roll of film having upon it a record of the producer's scene from the word "start" to the word "stop."

Turning Crank. At the top of the illustration of the Urban camera is a round window in which a finger moves over a scale marked 10-12-14-16. When the handle is turned, this hand indicates the number of pictures per second which are being taken. The usual speed is fourteen pictures per second. Turning the crank at a uniform speed of fourteen pictures per second, without variation in the speed and without shaking the camera upon its tripod,

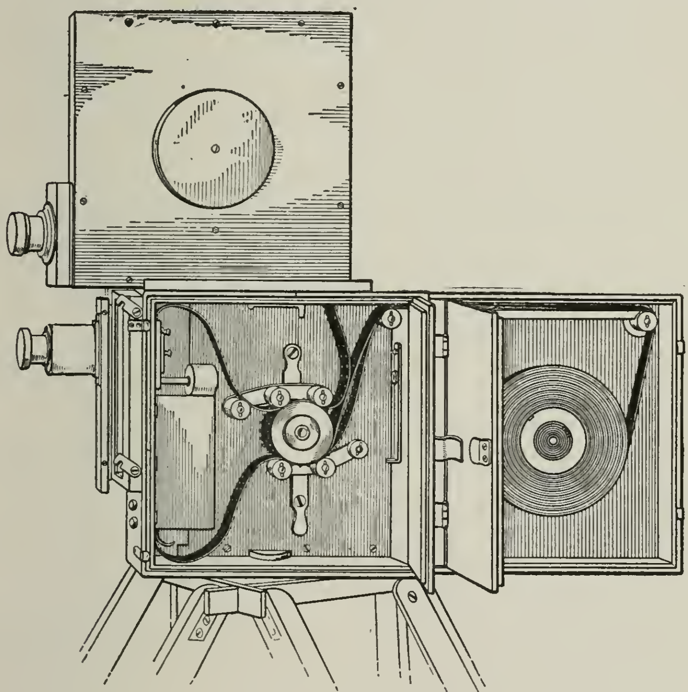


Fig. 14. Gaumont Camera

can be done only after much practice. Variations are liable to occur in every turn, the inexperienced camera man turning faster as the handle comes down and not so fast as it is passing backward at its lowest position. They are liable to occur also by steady increase or decrease of speed, starting a scene at fourteen and finishing it at the rate of ten or eighteen pictures per second. When the actors are playing their parts in the scene, the producer is prompting them and the action becomes interesting or exciting, the new camera man is liable to become interested or excited also and either turn the crank so fast that his negative is spoiled or forget to turn it at all.

Practice may be had by turning the camera crank without film. The length of exposure is dependent upon the speed of the crank. If the crank is turned faster as it comes down, the exposure will be shorter for the picture made then, and in the negative every fifth or sixth or eighth picture will be under-exposed as compared with the remainder of the negative. Such a negative cannot be used because a print from it would show similar variations and the result for the audience viewing the projected picture would be disagreeable.

The crank must be turned without shaking the camera. If the operator throws his weight upon the crank in any part of the turn, the tripod will yield slightly and change the view in the film window by shifting it slightly up or down or sideways. This shifting will occur periodically with each turn of the crank and the result is a strange waving or surging effect in the projected picture. To turn a crank uniformly in all parts of its revolution, the elbow may be placed in line with the center of the crank shaft and the crank turned with a movement of the forearm only, keeping the elbow still. In this way, the operator's weight is not thrown upon the crank and a steady rate is obtained.

The beginner must keep his eye on the speed gauge until turning becomes automatic. If there is no speed gauge, the best plan is to count while turning, and not to look at all at the action in the scene.

Cameras have been built to give three, four, five, six, or eight pictures for one turn of the crank. Four, six, and eight are in common use. The number of pictures, not the number of turns of the crank, is the end desired, and this means different crank speeds for different cameras. With eight pictures per turn—the speed most commonly met in modern professional cameras—fourteen pictures per second are obtained by turning the crank at the rate of 105 turns per minute; at six pictures per turn the crank speed required is 140 turns per minute. Many watches tick five ticks per second, 300 ticks per minute. Get a watch ticking 300 per minute and learn to count one-two-three, one-two-three, one-two-three, just as fast as the watch ticks, turning the crank one turn for every one-two-three, and the crank speed will be one hundred turns per minute, which is near the proper speed for an eight-picture camera. Count one-two, one-two, one-two, for the ticks of the watch and turn the crank of a six-picture camera one turn for each one-two. Useful practice may be had by turning the crank and holding the watch to the ear, a plan feasible even when actually taking pictures in the field. The greatest precautions must be taken by the new camera man to prevent the action of the scene taking his attention from the crank.

When the trick handle is used, it is to be turned at the same speed as the main handle, as though the full number of pictures were being taken.

To secure the best results with the panoram handle, it should be operated by an assistant, but with practice passable results may be obtained by one operator, turning the picture crank with one hand while he turns the panoram handle at a different rate of speed with the other hand.

Setting up Camera. The camera must be rigid upon its tripod, and it must be level. A level may be built into the camera case, or a small pocket level placed upon the top of the camera will serve, the level being tried both crosswise and lengthwise of the top of the camera. To "find" the view properly it may be necessary to tip the camera front up, but only ludicrous results will be obtained when the camera is not level crosswise. In the absence of a level, step back a few feet from the camera and "sight" it against the horizon line or some neighboring building. It is almost the universal rule in making pictures of dramatic action with natural settings to set the camera upon a portable platform probably 4 feet high, thus bringing the lens of the camera above the heads of the actors and of passers-by. This elevation also enables the camera man to arrange his image with the horizon line above the top line of the picture and thus cut out any signboards, fences, and houses of the extreme background.

Lens Length. The standard length for moving picture lenses is 3 inches. This gives an angle of view of about twenty degrees; a 2-inch lens gives an angle of about thirty degrees. The camera must include in its film window as much of the scene as the producer desires, and the producer must know, particularly in a natural setting, just where the limit lines of his scene are located, that he may keep his actors in the film window when they are supposed to be in the scene. More of the immediate foreground may be included in the film window image by moving the camera stand back, but where this cannot be done a similar result may be had by substituting the 2-inch lens for the regular 3-inch lens. When too much of the foreground is included, the camera may be moved forward or a 4-inch lens may be substituted. The camera man whose camera has but one lens will find himself at his wits end sometimes to include in the view just what the producer wants and no more. The most useful lenses are the standard (3-inch) and the "wide-angle" (2-inch). Lenses of 5-inch focus or longer are useful only in travel work for taking scenes and views of objects which cannot be approached closely, and for making pictures of trick or spectacular nature. Lenses of great focal length will require extension mounting tubes, since there is no bellows extension for the increase of distance between the lens and the film window.

Focusing. The motion-picture camera has no bellows, but is focused by sliding the lens in its mount. The barrel may have a rack and pinion with knob for racking the lens in and out, or the lens may be mounted in a screw flange and may be moved backward and forward by turning the lens in the mount. A limited movement only is thus obtained as compared with the movement of the bellows of a fixed camera; but in the motion-picture camera the very short focal lengths of the lenses require but small movement for their maximum adjustment for focus.

It is convenient to have the lens mount so arranged that when the lens is as far back as possible, at the limit of its motion, it is in universal focus for its largest or most commonly used aperture. By "universal" focus is meant that position of the lens in which distant objects are in focus upon the screen, nearer objects being to some extent blurred. At $f/16$, objects from the extreme distance and up to 30 feet from the camera are all in focus with the proper adjustment; with $f/32$, objects up to 20 feet; at $f/6.3$, objects up to 100 feet. The lens position for universal focus depends upon the diaphragm stop used.

In a crude camera it may be necessary to open the camera case and focus by looking directly upon the film window. The camera should have a focusing window for enabling the operator to see the image in the film window without opening the camera. This window may be either in front of the film or back of the film, and of course must be closed after focusing to prevent leakage of light to the film while being exposed by the crank. As the distance from the focusing peephole to the image in the film window is several inches, it is customary to have a lens for focusing which both enlarges the image, making accurate focus easier, and inverts the image so that the view is seen right side up.

Focusing may be done either upon the sensitive film which has been threaded through the camera mechanism, or a piece of very thin ground glass or of celluloid which has had its surface "ground" similar to ground glass, which may be placed in the film window for focusing, being removed and the film threaded up after focusing. Particularly for work in a city street is it desirable for the operator to set up his camera, get his field and focus, and be ready to turn in the shortest possible interval, and particularly for such work will the dead stop for universal focus be found desirable.

Control of Image. Aside from lens length and point of view, the operator has the sliding lens board, the equivalent of the rising and falling front of the fixed camera. The short focal length of the lenses used requires caution in using the sliding lens board, since the definition of the image is sacrificed when the center field of the lens is not used. The sliding front may be assisted by tipping the camera slightly when the resulting distortion is not objectionable.

The camera man's most powerful element of control of image is found in the selection of the point of view, and his tactful control of the producer in avoiding objectionable camera positions and in obtaining such camera stands as will lend some pictorial value to the images of the film window.

Shutter. The disk shutter is universal for cameras. A disk of thin sheet metal revolves in a plane between the lens and the sensitive film in the film window. An opening is cut in the shutter, or a part of the disk is cut away, and the light is cut off from the film by the shutter except while the opening is passing the lens. The opening is adjustable.

Such a shutter usually is made of two half-disks mounted upon a shutter shaft; by setting these exactly over each other, the shutter will be "half open, half closed," or by adjusting them upon each other the open space may be reduced to any desired fraction of the "open" area. Some shutters are provided with adjustments whereby the shutter exposure may be changed while the camera is being turned. This is objectionable because it renders the shutter more liable to getting out of adjustment accidentally.

Exposure Time. The usual exposure is "three-eighths open." When taking pictures at the rate of fourteen per second, this figures out $\frac{3}{8}$ of 1/14 of a second, 1/37 second, or 27/1000 second, that the lens is open. The photographer experienced with shutter efficiencies in fixed camera work may note that this is an actinic value and not a mechanical value, and that the exposure mechanically is correspondingly of greater value than the figures seem to show.

One-thirty-seventh of a second actinic value is much more than the average of snap-shot hand camera exposures. It is a longer exposure than would be possible with the fixed camera for moving objects and longer than is customary with hand cameras. Moving objects will show a blur in the negative; when projected upon the picture screen, the blurred object of one image will fade into the same blurred object in a different position in the next image, and smooth motion will be simulated, the object becoming sharp again when its motion becomes slower.

Exposure Control. The time or length of exposure being fixed by the mechanical limitations of the art of the motion picture, and the negative film being of but one available speed or sensitiveness, the sole means remaining to the camera operator for adjusting his exposure value is the diaphragm stop. If the light is poor, the stop must be opened, and if the stop at its full does not give enough light, the picture cannot be made unless by "trick" processes. In the matter of limiting quantity of light, however, two elements come to the relief of the motographer. *First,* because the negative is to be used for printing a transparency, a negative may be of value which would be useless for opaque paper prints; and *second,* the motion in the projected film picture will keep the attention of the spectator on the high lights and cause him to overlook the lack of detail in the shadows. Successful motion pictures may be obtained from exposures so low in light value that nothing but failure could result with the fixed camera.

As the diaphragm stop is the only variable element available to the motographer, Table I has been prepared giving the proper diaphragm stop for each day and hour of the year, Eastman film (Watkins 250, Wynne 111), $\frac{3}{8}$ open, 14 pictures per second (1/37 second), latitude of the northern part of the United States:

TABLE I

Exposure Chart

	Jan.	Feb.	Mar.	Apr.	May June July	Aug.	Sep.	Oct.	Nov.	Dec.
5 A.M.	......	......	......	......	*f*.8	.....	.....	.....	.. ..	.....
6 A.M.	.....	......	*f*/8	*f*/11	*f*/16	*f*/11	*f*/8	......	......	......
7 A.M.	*f*/4	*f*/11	*f*/16	*f*/22	*f*/22	*f*/22	*f*/16	*f*/11	*f*/4	*f*/4
8 A.M.	*f*/11	*f*/16	*f*/22	*f*/22	*f*/22	*f*/22	*f*/22	*f*/16	*f*/11	*f*/11
9 A.M.	*f*/16	*f*/22	*f*/22	*f*/32	*f*/32	*f*/32	*f*/22	*f*/22	*f*/16	*f*/16
10 A.M. to 2 P.M.	*f*/22	*f*/32	*f*/32	*f*/45	*f*/45	*f*/45	*f*/32	*f*/32	*f*/22	*f*/22
3 P.M.	*f*/16	*f*/22	*f*/22	*f*/32	*f*/45	*f*/45	*f*/32	*f*/32	*f*/16	*f*/16
4 P.M.	*f*/11	*f*/16	*f*/22	*f*/22	*f*/32	*f*/32	*f*/22	*f*/16	*f*/11	*f*/11
5 P.M.	*f*/4	*f*/11	*f*/16	*f*/22	*f*/22	*f*/22	*f*/16	*f*/11	*f*/4	*f*/4
6 P.M.	......	......	*f*/8	*f*/11	*f*/16	*f*/11	*f*/8	......	......	......
7 P.M.	......	......	......	......	*f*/8	......	......	......	......	......

This table is subject to all of the corrections given for the exposure table for the fixed camera. "Double exposure" for the motion-picture camera means only the next larger diaphragm stop, that is, the next lower number. "Four times exposure" means two numbers lower, and so on, each lower number doubling the exposure. "Half exposure" means the next stop number higher than the one given in the table. If a ray filter be used, the diaphragm stop must be opened to compensate, two stop numbers lower for a "four times" filter, one stop number lower for a "two times" filter, or three stop numbers lower for an "eight times" filter.

Eastman film is orthochromatic, and gives color values and cloud effects when used with an orange ray filter. It is of the sensitiveness used for "speed Kodaks," one and a half times as fast as ordinary Kodak film, and twice as fast as a Seeds 26x dry plate.

In addition to all of the corrections for clouds and nature of subject, as used for fixed photography, a quarter of the exposure may still be sufficient in view of the nature of the motion picture and the tendency of the spectator to view the high lights of the moving objects and neglect the shadows.

In computing an exposure, the object in motion is the center of interest, and all other parts of the picture are negligible. For instance, in a picture of an airship outlined against the sky, the sky correction (one-tenth exposure) is correct even though there are foreground objects; when the picture is projected, the spectators will look at the airship, not at the foreground. In a scene where one actor occupies the center of the stage and the play of expression in the face is the only action of the scene, it is poor motography to over-expose the white face for the sake of getting detail in the half-lighted studio background at which none of the audience is looking.

Exposure Meters. The exposure meter used for fixed-camera work is entirely suitable for motion-camera work, the speed of the motion-picture film being taken as 250 Watkins or 111 Wynne. Two further points must be borne in mind. *First,* that the 1/37 exposure given by the motion-picture camera with its 3/8-open shutter working at fourteen revolutions per second is full actinic value for the time, the equivalent of a focal plane shutter in a fixed camera, and much greater value than the similar schedule of the automatic leaf shutter common on fixed cameras. *Second,* that the motion-picture negative will stand an under-exposure of a quarter exposure or even less than that and yet give a successful print. To judge by the product of some studios and factories, the manufacturers prefer their films that way.

In using the Wynne meter, the light value or "actinometer time" is taken in seconds and the number of seconds thus found is set up opposite the plate speed number. The number representing the seconds of sun time is found upon the inner scale and the speed (111) of the motion film is found on the outer scale of the meter. These two are brought together. Now opposite the exposure to be given, read the diaphragm stop to be used. The exposure 1/37 is the line between 1/32 and 1/45. In the illustration, the sun time six seconds is set opposite the film speed 111, and opposite the 1/37 exposure line is read a diaphragm stop between *f*/7 and *f*/8.

In using the Watkins meter, the light time is taken in seconds and is set opposite the 1/37 exposure; opposite the film speed 250 then is read the diaphragm stop to be used. Thus, when a light time of 3 seconds is taken, 3 on the light scale is set between 1/32 and 1/45 on the outer ring which is both exposure and plate speed scale. Opposite 1/250 will be read either U. S. No. 8 or *f*/11.

In using any meter in the field, the correction for the nature of the subject, and for the allowable or desirable under-exposure of the film, is always to be made. If the camera man should find that his critics or "bosses," whosoever they may be, prefer thin negatives resulting from under-exposures, the film speed may be taken as Wynne 256 or Wynne 512 and the meter scale will give directly in its scale reading the required diaphragm stop with the correction for under-exposure—as compared with fixed camera work —as desired.

In the daylight studio, the meter will show the value of the daylight upon the scene set, and will give the stop required. If the stop required is larger than can be had in the lens, the meter will show by a proper interpretation what proportion of the necessary light is had, and the remaining proportion of light may be supplied by lighting a partial battery of lamps.

In the artificially lighted studio scene, the exposure is constant and is known from experience, being always the same, day or night, scene after scene.

The exposure value for a scene lighted with standard Cooper-Hewitt mercury-vapor lamps rated at 700 candle-power may be calculated according to the following formula:

Take the average distance from all lamps to waist height of an actor standing in the middle of the scene set, measured in number of feet. Multiply this number by itself, divide by ten times the number of lamps, and the quotient is the correct exposure at f/16. Thus, with 100 lamps averaging 10 feet from the middle of the stage setting, the solution is $10 \times 10 \div (10 \times 100) = 1/10$ second at *f*/16, or 1/40 second at *f*/8. Therefore, for such a setting, stop *f*/8 should be used.

Where the light is insufficient, it is possible to open the shutter of the camera to ½-open-½-closed, thus increasing the exposure by one-third of its light value. By turning the camera slowly, the exposure value is further increased, but this can be done only with the result of speeding up the resulting action when the print is projected. It is the producer's option, not the camera man's.

Panoramic views of poorly lighted scenes without moving figures, as the interior of churches, court yards, statuary, conservatories, etc., and factories with the machinery motionless, may be made by lengthening the exposure by turning slowly, but only by the most skilful actors is it possible to put any lifelike movement into such a picture.

Duplicate Exposures. Exposure values are always doubtful even when calculated from the meter. When two cameras are working side by side to make duplicate negatives of the same scene, it is well to have the diphragm stop of one camera one number or even two numbers above the other, giving the developing room a better chance to get one really perfect negative out of the pair of films. Duplicate exposures upon a scene are made for several reasons:

That one negative may be held in reserve in case of accident in a printing machine or elsewhere.

That two exposures may be available in case of accident before or during development.

That one negative may be exported for printing abroad.

That two films may be exposed as assurance against accident in one of the cameras.

That cameras of different makes may have their products confused.

Trick Crank. The main crank gives a large number of pictures per second, and the camera operator acquires a skill in turning it which enables him to take fourteen pictures per second with great precision. When it is desired, for trick picture purposes, to take the pictures at a slow speed—that the action may be speeded up in projection—it is possible to turn the main crank at half speed, but better to use a "trick" crank, which the camera man may turn at his normal accustomed speed. This trick crank is geared down in the camera and gives only half the inside speed, or less, sometimes making only one picture per turn of the crank. The opening in the shutter must be changed accordingly, half the opening for half the picture taking speed, in order that the exposure time of 1/37 second may be maintained. Correction by the diaphragm is possible, but results in too much motion in the object if rapidly moving. Where the main crank is detachable, it may be put on either the main shatf or the trick shaft of the camera.

SCENE FROM PHOTOPLAY, "THE ROSE OF OLD ST. AUGUSTINE," OR "A TALE OF JEAN LAFITTE, THE PRIVATEER"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

THE POPULACE PREPARING FOR THE REVOLUTION IN PARIS
Scene from the Vitagraph Life Portrayal of "A Tale of Two Cities"
Courtesy of the *Vitagraph Company of America*

Reversing. The camera may reverse the action in three methods, of which the third mentioned is the usual one employed. *First,* some cameras are so constructed that the handle may be turned backward or forward. When making reversed scene with such a camera, load the film into the take-up position and the take-up box into the feed position, then change the take-up belt or gears to wind upon the feed spindle position which now is reversing take-up. *Second,* mount a reversing prism in front of the camera and turn as usual. *Third,* the camera is provided with a tripod screw or socket in the top. Turn the camera top down on the tripod, and turn as usual except that the crank now is upon the opposite side of the camera from that to which the operator is accustomed.

Finders. A finder for focusing is not convenient for determining the view while panoraming. It is possible to panoram accurately by sighting along the side or top corner of the camera, particularly when two operators are working the camera, but when there is but one and he stands at the side of the camera, turning two cranks at the same time, a finder bringing the view into convenient position will be an advantage.

Indicator. A film-measuring device works upon the constant feed of the film and has its dial outside. The indicator can be reset by the operator. The operator sets the hand to zero when loading the camera, and the hand then will read upon the scale the length of film turned through. Knowing the length put into the camera when loading, the operator can by subtraction know the length still remaining. When not enough film remains for the next scene, the camera must be reloaded, the lens being capped and the film "marked," and the remainder of the film wound through into the take-up box before opening the camera to reload.

It is possible to make the dial of the film indicator read "remaining film" instead of "used film," the operator setting the hand backward to the equivalent of the film length when loading the camera, and the hand reading upon the dial at all times just the amount of film remaining as the hand approaches zero.

Marker. The marker is a push button or pull knob on the outside of the camera, and usually operated to punch a hole in the film near the film window. Its use is to indicate on the film the end of a scene. For the benefit of the developing room, a "test exposure" of a few feet of film is made before beginning the taking of the scene for the final motion picture negative. The camera is set up, focused, and closed ready for use, the light-struck leader is turned off into the take-up box, and then several turns of the crank are given, exposing a dozen feet of the film before the action is ready to begin. The "marker" then is operated to punch a hole in the film, or two or three holes with single picture space between them. The scene then is taken. In the developing room, the leader of film ahead of the marker holes may be cut off and developed to learn whether the exposure is correctly timed, and whether regular or special developer shall be used in the development of the scene of the film.

When the unused film in the camera is not enough to cover the length of scene which the producer is about to enact before the camera, the marker is operated again and the remainder of the film wound through. A memorandum of the number of feet of unexposed film is sent with the reel when it goes back to the factory, that length is measured off and the film is cut at the marker holes, thus saving the unused film.

Bianchi Camera. This camera does not use the intermittent motion, but uses a continuously moving film and passes the rays of the image through a revolving prism. The only difference to the camera operator is the method of threading up the film.

Hamacek Camera. This camera uses no sprockets, and the film is not perforated. The method of use is in all ways similar to the camera using perforated film, except in the detail of threading.

No matter what the mechanism of the camera, the operator should understand it thoroughly, and keep it clean, properly oiled, and in perfect adjustment and running condition.

Factory Floor Plan. Fig. 15 shows a floor plan suitable for a small motion-picture film factory. This shows only the "photographer's" department, the sales offices and the studio being adjacent or elsewhere.

The plan is self-explanatory outside of the developing room and the light-trap entrance to the developing and printing rooms. The perforating room is entered only through the printing room. Partitions form a tortuous pathway into the developing room and printing room from the shipping room, permitting the free access to and from these rooms without doors, and without danger of accidental light flashes into the rooms by reason of the opening of the doors. At the end of the developing room next the washing room a large door shown double is of sufficient size to permit a developing cage to pass through. Because of the opening of this outer door to the developing room, there is no door between the printing room and developing room, passage being had through the entrance passageways, or by a turntable in the partition.

Development of Films. *Cages.* For development, the exposed or printed film is wound spirally upon cages 3 feet in diameter and 5 feet long, one such cage taking a 200-foot roll of film. The ends

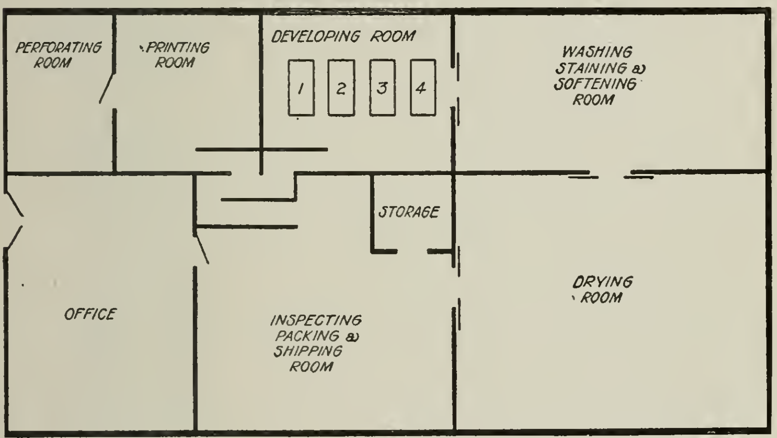


Fig. 15. A Film Factory Floor Plan

of the cage are built like wheels of fellies and spokes, the ends being connected by round polished wood rods, the whole appearing like a large cylindrical cage with an axle through the center.

Trays. The developing tray is of wood, 6 inches deep, and has within it a zinc trough curved with the curvature of the developing cage. Standards at the ends of the developing tray take the axles of the developing cage and support its surface within $\frac{1}{2}$ inch of the bottom of the zinc tray which it fits closely but does not touch, turning freely on its axle. A few gallons of developer in the zinc tray will develop several cages of film, the cage being turned constantly during development. The wood tray catches what developer splashes over the zinc.

Trays for washing do not have the inner zinc trough, being filled with water, running water if convenient. The hypo trays also should have an abundance of hypo solution, and do not require the inner zinc trough for economy of solution as is the case with the developer.

Room. Four trays are shown in the floor plan, No. 1 developer, No. 2 water, No. 3 water, and No. 4 hypo fixing bath. The cages are handled by the developing room operator and an assistant, lifting at the two ends of the axle. The routine of development is as follows:

Developing. Through the large door, a developing cage is brought in and hung over the developing tray on high journals, a few inches above the developer. The large door being securely closed and the room lighted by red light only, the operator opens a tin box of exposed film, attaches one end with a clamp to one of the slats of the cage, at one end; the assistant turns the cage and the operator feeds the film on from the roll, attaching the end when all is fed on. The cage now is set down on lower journals and turned in the developer by the assistant while the operator watches the images until fully developed. The cage then is lifted to the wash water tray, turned a few times, then to the second wash water and turned a few times, then to the fixing bath. When the milkiness is gone, the big door is opened, the cage with the wet film is carried out to the washing room, and another empty cage is brought in and the big door closed again.

Washing. Two assistants in the washing room wash the film through several waters or in running water to free it from hypo, then turn it in a tray of diluted glycerine—1 part glycerine, 33 parts water—for a minute and carry it into the drying room.

Drying. The drying drums differ from the developing drums in having smooth surfaces instead of being cylinders of slats. Also, they may be larger than the developing cages, since they do not have to be handled—4 feet in diameter by 8 feet long is reasonable, and will hold 600 feet of film. Two attendants are required in the drying room. The end of the film is attached to the drum with a thumb tack and one attendant turns the drum by hand, while the other attendant guides the wet film from the developing cage to the surface of the drying drum. When the end is reached, it is attached with a tack or push pin, and the drying drum is belted to a motor which drives it continuously until the film is dry. The developing drum is sent back to the washing room for use again in the development of films.

When films are dry, they are unwound from the drying drums to reels or into baskets and taken to the inspection room, if positives, for shipment, or sent to the photographer for inspection and proofs, if negatives.

Making Titles. The making of a title is a simple case of the making of a motion picture of an object which as a general rule is not moving. The titles are set up and properly lighted and photographed with a motion-picture camera, using the length of film called for by the synopsis. Most conveniently, titles are prepared in batches, a number of titles being photographed upon a long strip of film which then is developed in the usual way and a proof print taken. The titles then are cut apart and spliced into the motion scenes as required for the complete film pictures.

To make titles with movable letters, a table top is covered with black cloth and a motion-picture camera is permanently mounted above it and focused upon the surface of the table. Lamps are placed around the table for lighting the title. The light need not be excessively bright, as the camera may be turned slowly and with a large shutter opening.

Upon the table top, white letters are arranged to form a title, the title is photographed by turning the camera above the table, and the letters immediately are arranged again for the next title. Letters cut by dies from white paper may be bought in various sizes, or porcelain letters, such as are used for signs on window glass, also are obtainable in various sizes and in various styles of lettering. Lines upon the table top show the edges of the field of the camera and within the lines the desired title is formed, arranging the letters of each line against a straight edge which is removed before photographing.

The table top is a convenient means for copying all kinds of titles, merely laying the title upon the table, if the suspended camera is arranged so that it can be moved to different heights to provide for different enlargements of the various titles, and further arranged so that it can be focused conveniently.

In photographing either a yellow telegraph blank printed with black ink or a white telegraph blank printed with blue ink, a heavy yellow ray filter should be used over the lens to increase the contrast in the resultant title.

A suggestion for the photographing of titles is that a slow film be used for the negative instead of the extremely fast sensitive film used for the motion scenes, since a slow film will give a greater contrast in the resulting titles.

A reversed title is made as follows: With a title in black letters on a white card, photograph the title and develop as usual; this negative has clear letters on a dense background. Make a reversed print by printing with the celluloid side of the negative against the gelatine side of the printing stock. This print when examined will have its letters reading backward, like a negative, but will have black letters on a clear background. This reversed print is the reversed negative, to be spliced in with the negatives of the motion scenes for printing the titles for the finished pictures, the printing for the final scenes being gelatine to gelatine, as for the motion scenes. In the print, the reversed title will appear with clear letters upon a dense background, making the title when projected show white letters upon a black screen.

Printing. *Room.* The proper location for the printing room is between the perforating room and the developing room, as shown in the floor plan of Fig. 15, with entrances into both perforating and developing rooms as conveniently arranged as possible. The printing room constantly requires supplies of perforated film from the perforating room, and constantly supplies the developing room with printed film for development. The connection between the printing room and the developing room is particularly close, since by immediate development of the film after printing the developing room operator may be able to note errors in printing which might spoil large quantities of film if printed far in advance of development. The printing room is provided with printing machines and power to drive them.

Machines. Obviously, a negative for a reel of film 1,000 feet long cannot well be handled in a contact printing frame such as is used for printing the negatives from a fixed camera, nor is it practicable to cut the negative into sufficiently short lengths for such contact printing even if proper results could be obtained in that manner. Since the standard roll of film furnished by the makers of the raw film is 200 feet, and since the developing cages are also of a size to handle the 200-foot rolls of film, the 1,000-foot negative is cut into five pieces of 200 feet each and the 200-foot length is the standard length through the factory up to the time for splicing together into the reel for shipment to the film exchange.

The printing machines are of two types, stepping and rotary. The *stepping printing machine* has a film window and an intermittent film movement. There is no lens. An incandescent lamp is arranged to shine upon the film window, being adjustable in distance from the window. The lamp is enclosed, to prevent leakage of white light into the printing room, and the film window is backed with ruby glass to permit the operator to see the image in the window and to prevent leakage of white light. A framing device is a desirable feature of a stepping printing machine, and a necessity if the intermittent film movement is not entirely reliable. A projecting motion head may be used as a printing machine, or in the case of amateur work the lens may be removed from the camera and the camera may be used as a stepping printing machine. The projecting head has the framing device, while the camera has not, and either requires the printing lamp with its adjustment for distance to be added, after removing the lens.

Two feed reels are provided, one for the negative and one for the raw positive film stock, the two ends being started through the film window together, film sides together and the negative next the light, so the light shines through the negative upon the positive. The shutter remains upon the machine. The operator then applies the power and keeps the image framed in the film window. A take-up reel rolls up the printed positive film, but it is customary to run the negative into an open basket and to rewind it before making the next print, so that the printing always proceeds from the same end of the negative. The stepping machine will print from 10 to 100 feet per minute.

The *continuous printing machine* is much faster in operation than the stepping machine, printing from 40 to 500 feet per minute according to the quality of the negative, but the greater perfection in mechanism required renders the continuous machine difficult to construct, and the greater accuracy required in adjustment and operation sometimes results in losses of film not encountered with the stepping machines; and if the defective film be not discovered and discarded, then the manufacturer is giving to his customers an inferior product, which is the worst condition of all.

In the continuous machine, the two films, negative and positive, are wound with a steady motion from the feed rolls to the take-up rolls, passing together in contact in front of a window lighted with the printing lamp. This sounds very easy, but the slightest slipping of one film upon the other will produce an effect upon the picture screen when projected which will drive a spectator to insanity, and the slightest lack of registration in the perforations of the two films will produce the undesirable slipping.

Exposure. By the term "exposure" in printing, the same meaning is conveyed as in using the camera, namely, the amount of light which is permitted to pass to the sensitive film. In the printing machine this depends upon the intensity of the printing light in the window, the size of the window or shutter opening, and the speed at which the printing machine is driven.

With either the stepping or continuous machine, the amount of exposure may be regulated without stopping the machine by changing the distance of the printing lamp from the film; doubling the distance cuts the exposure value by four; and dividing the printing-lamp distance by three, multiplies the exposure value by nine, according to the law of squares.

With either the stepping or continuous machine, the amount of exposure may be regulated by changing the speed of driving the machine. This regulation does not apply the law of squares but gives a lineal inverse ratio to the exposure, half the speed giving double the exposure, double the speed giving half the exposure, and so on.

With the stepping machine, the opening of the shutter may be changed from $\frac{1}{2}$-open to $\frac{1}{4}$-open or $\frac{3}{4}$-open, the change in exposure value being in direct ratio to the size of the open portion of the shutter. It is possible to construct printing machines in which the shutter opening may be changed without stopping the machine, inasmuch as some motion-picture cameras have this feature in the shutter and such a camera shutter may be used in a stepping printing machine.

With the continuous machine, the size of the film window or slit of light shining upon the film may be changed without stopping the printing machine. The printing window or spot of light which impresses the image upon the positive film as the two films pass may be large enough to cover a full image, or two images, or may be only a quarter of an inch in width, or even narrower, extending always from side to side of the film. The narrower this band of light, the less injurious to the resulting print will be any lack of accuracy in the adjustment of the printing machine, or in the perforations of the two films. With a narrow band of light, the printing lamp must be nearer, or brighter, or the speed of the machine must be slower.

Incandescent electric lamps are used because of the uniformity of their illuminating power.

Film Adjustment During Printing. The 200-foot piece of negative is composed likely of half a dozen motion scenes, some inside studio work and some outdoor work, interspersed with titles. That all these short negatives, made under varying conditions, should have the same printing density and require the same exposure in the printing machine is quite unlikely. Each 200-foot length of negative is inspected by the chief photographer and ticketed for exposure. Following is a sample exposure ticket for a stepping printing machine having lamp distance as its only adjustment while moving.

First Negative, "The New Boarder"
Speed 25 feet per minute
Shutter $\frac{3}{4}$-open
12′ title 3″
30′ interior scene 10″
6′ title 3″
20′ interior scene 10″
10′ outside scene 8″
60′ interior scene 10″
6′ title 3″
40′ outside scene 6″

The number of feet given at the beginning of each line of the ticket indicates the length of film which is taken up with the title or scene, that the printer may anticipate the instant when the next change is to be made. The exact instant is known in a stepping machine by watching the images of the negative in the film window. In a continuous printing machine, the images are blurred by the steady motion, but the change in density of the negative will be noticed, and further guidance may be had by cutting a small notch in the edge of the negative film and arranging an electric circuit to tap a bell as the notch passes.

The lamp of the printing machine is movable by a lever which is provided with pointer and scale and with movable stops which may be set to stop the lever at different lamp distances. To print the negative ticketed according to the specimen ticket given, the printer sets stops permanently at 3″ and 10″, the limiting positions, holding the lever against the stops for that portion of the negative for which those stops are correct, and holding the pointer on the scale at the proper number for other sections of the negative.

For use with a continuous machine, the exposure ticket would give at the head the film speed and slot width, or would give at the head the speed and lamp distance and then give the slot width for each portion of the negative, the adjustment being made by slot width rather than by lamp distance.

Making the Exposure Ticket. By experience, the photographer in charge can judge the printing exposure required by looking through the negative, or comparing it with standard specimens. The first print should be developed promptly and inspected, the ticket being changed if required. In case of doubt before printing, the negative may be run through the printing machine under known conditions with a foot of positive film, this foot being attached to the developing drum with tacks while a roll is being developed. By the resulting specimen print, the proper exposure may be judged.

Developing Prints. Processes suitable for developing lantern slide plates in fixed camera photography are suitable for the motion-picture positive prints. Hydro-metol or hydro-quinone developer are usual. The positive print is developed, washed, fixed, washed, softened in glycerine, and dried.

Inspection. After drying, the prints are carefully looked over, foot by foot, for defects of any character whatever. The five 200-foot pieces of each 1,000-foot reel then are spliced together in proper order and the reel is ready for packing and shipment. Isolated defective images are cut out and a splice made. Where more than a limited number of images in one place are found defective in the print, the place is marked and a short length printed from the negative and substituted for the defective length of film. Hand staining, hand coloring, and hand spotting of the prints are done in the inspection department unless of such quantity that a special department is created for the work. After passing the inspection, the film is packed in its sheet iron shipping cases, one reel in a case, and sent to the storage room until required for shipment.

Print Spotting. Very little hand work is done upon the print after it is dried, but sometimes a reel of negative will have a scene which requires hand work on each print to bring it up to the standard of the factory, or to make it passable at all. If the scene cannot be retaken to secure an improved negative, the hand work upon the prints must be done. In many instances, it is possible to balance the cost and inconvenience of necessary hand work upon prints or negative against the cost of reproducing the scene and securing an improved negative.

Staining. Staining of a print is done in the wash-room as a part of the washing process, and is done in the same manner that a laundress uses in bluing her clothes. The last rinse water, or the glycerine bath, or both, are charged with an aniline dye or other water-soluble dye stuff, and the film takes the color in passing through the baths. This produces a stained gelatine film on which the silver image is still black. When projected it produces a black picture upon a tinted screen. It is largely used for reversed titles, producing the title in tinted letters upon a black picture screen and giving a more pleasing effect than a plain white title. The Western Union Telegraph Company uses a yellow telegraph blank, and titles showing such messages sometimes are stained yellow to lend realism to the title.

Toning or Monochroming. In the toned or monochromed film, the gelatine remains clear and the shadows of the image are colored, giving the effect upon the picture screen when projected of a picture painted with color upon a white sheet. The processes may be classified as those which obtain the colored image in the first development of the positive film and those which obtain the color by subsequent manipulation.

With hydro-metol or hydro-quinone developer having no bromide or insufficient bromide, the image will come up in olive green. Because of the absence of bromide, the development is very rapid and difficult to control, and the printing exposure must be correspondingly short to secure a good print. With a proper adjustment of printing exposure, developer strength and bromide, neutral blacks can be secured. With a developer rich in bromide, development is slower and the resulting film shows shadows tending toward brown, and with still more bromide the print shows purple or even red. Printing exposure must be increased to avoid unduly prolonged development. With a printing exposure of ten times normal for black and a development period of ten times normal for black and with sufficient bromide in the developer to restrain the development to that period of time after that exposure, the resulting images will be a purple which tends toward red. Monochroming of this class is done in the developing room, before the print is passed out to the daylight washing room.

Processes in which the colored image is not obtained in the first development may be carried on in the daylight washing room, before the film is bathed in the glycerine bath. Re-developing for sepia, and intensification and toning for blue, green, and red may be done as for lantern-slide plates. The literature of the photographic art is amply provided with formulas for these processes.

Repeater Printing. Where it is desired to give a special tone to a single scene or short portion of a complete film picture, the negative for that scene may be omitted from the complete negative, a few inches of blank film or special code film being inserted instead. The short scene now is placed in the printing machine and the two ends stuck together, forming a belt. A 200-foot roll of positive film is started through the printing machine, and the belt of negative is printed repeatedly for the entire length of the positive roll, if required, or for as many rolls as are required. A large number of repetitions of a short scene thus may be developed and toned at once, being cut apart after drying and spliced into the regular prints at the proper place, the bit of dummy film put into the negative acting as a guide to the inspection room to put the special scene in its proper place.

Hand Staining. Titles or short scenes forming parts of long pictures and requiring staining may be done more conveniently by staining each positive print with a brush, by hand, than by special work in the developing or washing room and the subsequent splicing required in the inspecting room. One of the desirable features of hand-staining is that there is no danger of errors in the order of scenes in splicing up, since the splicing is avoided. The slight unevenness of hand-staining is entirely negligible in reversed titles. Hand-staining is done in the inspection room after the film has been dried.

Coloring Films. *Hand Process.* The primitive method is to take the positive film and a set of brushes and water colors and color each of the small images as though they were so many separate and distinct photographs, as indeed they are. In connection with this method of hand-coloring the intermittent mechanism of the camera or projecting machine may be used with great convenience. The strip of film to be colored is arranged over a glass plate through which the light may pass, since the colorist should look through the film to get the effect of the color. A leader is spliced (or pinned) to the film to be colored and is taken through an intermittent movement controlled by the colorist's foot upon a pedal, that by a single pressure upon the pedal the film being colored may be stepped forward one picture. This change will take place very quickly, so that the colorist seems to be working upon the same image. Taking the blue color for the sky, the colorist colors the sky of the first image, lifts the brush, and presses the shift pedal, proceeding to color the sky of the next image without lifting the hand from the position of applying the color, merely lifting the brush from the film while shifting the images. Having colored all the skies, a certain tree, house, or chimney is colored throughout the length of the scene; then the moving figures are colored, the brush of the colorist following the figure over the small picture as the figure moves in the action of the play. Taken in connection with the pedal shift, the coloring of some film scenes becomes surprisingly rapid. Hand-colored scenes are spliced up with monochromed and stained scenes and titles. A "full hand-colored film" picture has been reported by colorists as requiring a day's labor of a worker for each 35 feet of film. The time for different scenes will vary widely, and this 35 feet per day may be taken as a maximum of labor in hand-coloring.

Stencil Process. A stencil is made for each color to be applied to the film, and the proper colors are applied through the stencils with brushes operated by hand. Assuming that it is decided to color a scene with three colors, red, yellow, and blue: Four prints of the scene are taken by the colorist; upon one is painted with red all of the parts of each image which are to be colored red in the finished colored picture, just as the hand colorist would finish with the red before taking up another color. The colorist next takes the yellow, but takes also the second of the prints and colors upon the second print all of the parts which are to be colored yellow in the finished picture. The blue color and the third of the prints now are taken and all parts to be blue in the finished picture are colored blue in the third film print. By looking through all three of the prints together, the colorist may judge what the result of the combination of colors upon one print will be, and may change any of the prints. When finished, there are three colored prints, each of which bears but a single color. If more than three colors had been decided upon there would be more than three of the partly colored prints. The three prints now are cut with a sharp knife or with stenciling chisels, removing all of the colored portions and leaving all of the uncolored portions. The result is a set of stencils, in one of which every red spot on the finished colored motion film is indicated by a hole in the stencil, in another of which the yellow is represented similarly by holes, and in the third of which the blue is represented by holes.

The fourth print of the scene is taken, the red stencil is placed upon it and a brush charged with red ink is run over the stencil. The yellow stencil then is placed upon it after removing the red stencil and a brush charged with yellow ink is run over it. The yellow stencil being removed, the blue stencil is placed upon the film and a brush charged with blue ink is run over it. The result is a tri-color print with the colors stenciled upon the black lines of the photographic print. A monochromed or stained print may be stenciled over in the same way, producing desired effects.

Machine Process. The machine feature consists of the application of the ink through the stencil by a stenciling machine. An illustration from the published American patent of a French film coloring machine is reproduced in Fig. 16. The method of making the stencil is the same as for a hand-stenciled film. The operation is as follows: Having the stencil for one color, and the film to be colored, each in a roll, the roll of stencil is placed in the machine at *23* and the roll of film to be colored is placed at *24*. The ends then are taken through the guide blocks *25*, the stencil band being shown by the dotted line *2* and the film to be colored being shown by the solid line *3*. These are passed together over the large roller or drum *1*. Just above this drum there is a short endless band of ribbon *21*. This, the inventor tells us, should be of velvet, so that it offers a soft brushlike surface which is well suited to pass through the holes in the stencil band and touch the film to be colored, which lies just underneath. The band *21*, which is really an ink brush, runs over three rollers, and runs in a direction opposite to the direction of the film and stencil band, the directions of the movements of the parts being shown by the arrows close to the different bands; thus there is a considerable brushing effect between the inking band and

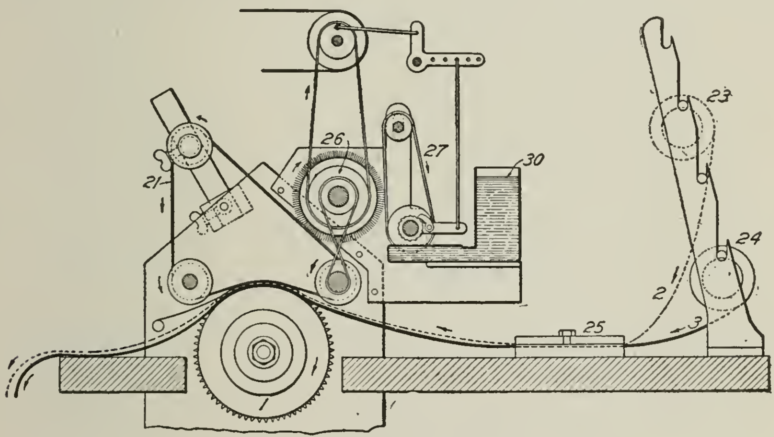


Fig. 16. Film-Coloring Machine

the film to be colored wherever a hole in the stencil band permits the brush band *21* to get through to touch the film. This charges the film with ink or dye, coloring it in every spot where the color is desired, that is to say, everywhere that a hole has been made in making the stencil band *2*.

The supply of ink is taken from the tank *30* and is carried first upon a short belt *27;* it is taken from the belt *27* and put upon the inking ribbon *21* by the revolving brush *26*. The whole device is driven by a belt and runs continuously, the teeth upon the drum *1* keeping the stencil band and the film to be colored traveling constantly at the same speed, and keeping them always in register.

As in hand stenciling, a separate stencil is required for each color, and the film to be colored is run through as many coloring machines, each having a different stencil and a different color of ink, as there are colors in the finished picture.

Waterproofing. The picture film is celluloid upon one side, gelatine upon the other. The celluloid side is hard, glossy, water-resisting, scratch-resisting, dust-resisting, but the gelatine side is easily scratched, collects dust in the scratches and sometimes without them, and is ruined by a drop of water, yet requires a moist atmosphere or it will crack by becoming too dry and brittle. In the process called "waterproofing" celluloid or a similar substance in solution is applied over the gelatine film, strikes through the film and unites with the celluloid body, forming a celluloid skin over the delicate film and imprisoning the gelatine like the ham in a railroad sandwich. After that treatment, both sides of the picture film are hard and scratch-resisting, and the film may be washed with water (by special machinery for the purpose) to remove dirt. At the same time, the moisture which made the film flexible is imprisoned with the gelatine and the film remains flexible. The process is patented. Either plain or colored films may be waterproofed, or the negatives in the printing room. The proper time for waterproofing is before the film is shipped for use.

Packing Films for Shipment. The films are shipped in full reels, or 1,000-foot lengths, wound with open center with the title end out. Each reel is packed in a circular, flat sheet-iron can and then in a wood box; this is a requirement of the express companies. A further requirement is regarding a danger label, which must be printed on red paper not less than 3 inches square, reading as follows: "*Moving picture films must not be loaded or stored near a radiator, stove, or other source of heat.*" The reason for the last rule is that celluloid when warm gives off explosive vapors.

Reclaiming Waste. Light-struck films develop black, and these may be sold to film exchanges for leaders. The punchings from the perforating room contain silver, and this may be reclaimed at a profit by a chemical process. The black silver in junk or spoiled film may be reclaimed but usually is not, and the same is true of the silver in the used hypo bath.

MARY IS BROUGHT BEFORE THE CHIEF
Scene from Photoplay, "Mary's Stratagem"
Courtesy of *G. Melies Company, New York*

SCENE FROM PHOTOPLAY, "THE INHERITANCE"
Courtesy of *Thomas A. Edison, Inc., Orange, N. J.*

PHOTOGRAPHIC EQUIPMENT

All supplies needed by the manufacturer, other than cameras, printing machines, perforating machines, and film stock, may be bought in any city in the open market.

Buying Cameras. Urban and other English and French cameras may be purchased and imported into the United States at costs ranging from $300 to $400; printing machines cost about the same prices as cameras, for either the stepping or continuous movement. The importation or manufacture of cameras in the United States is influenced by the patent situation. Cameras have been offered for sale in the United States at prices quoted from $475 to $2,500.

Making Cameras. A projecting machine may be converted into a camera, though rather bulky for field work and requiring some ingenuity to accomplish all the desired features of a camera for both studio and field work. A projecting machine with lens removed and a hooded lamp at the aperture becomes a printing machine almost without change. The pin or claw intermittent movement is preferable to the sprocket for cameras.

Buying Films. Several prominent makers of roll films for hand cameras have taken up the manufacture of film for motion-picture cameras and are supplying the market. The price charged is about four cents per foot, unperforated. From some dealers it may be bought perforated.

Fire Risk in Storing Films. A rolled film in its tin box is a perfectly safe proposition at ordinary temperatures. The celluloid body of the film, whether raw film, prints, or junk, gives off an inflammable and explosive gas, giving it off more rapidly when warm than when cold. A vault for storing films must have a vent; a slow but continuous draught of air through the vault seems a logical provision for safety.

CHRONOPHOTOGRAPHY

The requirement for scientific study usually is a clear sharp picture taken at regular intervals. The intervals may be short or long, either at the rate of several hundred pictures per second or at the rate of one picture per hour, or one per day. The results occasionally are of interest to the general public.

Motographic Microscopy. The image of the thing to be motographed is taken through microscopic lenses to the motion camera in a manner easily accomplished when the lenses are available. The greatest difficulty is found in illuminating the subject sufficiently to achieve the short motographic exposure without destroying the subject by the heat of the source of light. By carrying the light through water or an alum cell before it reaches the subject, and by operating a shutter between the light and the subject so that the light is cut off from the subject except while the exposure is being made, such relief from the heat may be attained as will permit making a motographic picture without destroying the thing motographed.

Motographic Ultramicroscopy. Ultramicroscopy is the name given to the process of microscopic study which makes use of the ultra-violet (invisible) rays, recording the image upon a photographic plate and studying it after development. Motographic film has been operated successfully with this class of microscopic study.

X-Ray Motography. The invisible X-ray penetrates many solids which are impenetrable by light, and the X-ray is able to influence the photographic dry plate or motographic film. Passing through the body, the X-ray is obstructed by the bones and the heavier and denser organs, throwing a shadow of them upon the photographic surface. By arranging the motographic camera with proper shutter and protective X-opaque shields for the reels and film, motion pictures of the heart in action, of circulation of the blood, etc., are possible.

TRICK PICTURES

There is no standard "box of tricks" beyond which lies nothing of interest. The interest never ceases when trick-picture making has been begun. This subject was opened under the discussion of tricks in the production of the specimen film, "High-Jumping Johnnie." The thoughts there given were but the simplest of tricks, easily understood or almost guessed by the audience in watching the picture. In addition to the tricks used so much that they may be considered standard illusions in motography, special effects may be attained by tricks as subtle as those of the accomplished magician before his audience. A few of the standard tricks of illusion are here described.

Reversals. The method is to show upon the screen the series in the order just reversing the order in which the pictures were taken. When this is done, all the characters would walk backward, objects would fall from the floor upward to the shelves and table, smoke would float down into the chimney, etc.

Means. Turn the camera bottom up on the tripod—by a tripod socket in the top of the box—this will reverse the action. Or print by a special printing machine which steps the film negative in one direction and the positive stock in the other direction.

Effects. A runaway horse may run backward and push the wagon before him just as easily as running forward if there are no people on the street who also would walk backward and thus reverse the illusion.

A witch desires to create money from a piece of tallow candle. She melts the candle and pours it on a surface to cool. From this point a picture of coin casts in tallow melting on the same surface is inserted reversed, giving the appearance that the melted tallow magically takes the form of coins and hardens. The witch then apparently picks them off as good coins magically created.

A sculptor makes a wonderful statue in record time, with a wealth of detail, by skilfully pulling apart a clay model before the camera, the film then being run reversed whereby he seems to build up, not to tear down.

A swimmer, having jumped into the water, by a reversed film jumps just as easily out again, landing safely upon the bank, pier, or springboard, feet first, every time.

Speed Pictures. When pictures are taken slowly and projected at the standard rate, the action of the picture seems correspondingly faster.

Means. Reduce the shutter opening and turn the handle slowly, or turn the camera mechanism, by a specially provided gear to a special handle or shaft called the "trick handle."

Effects. Chases may be made to appear much more rapid than they really are, and acrobatic actions on the part of a comedian in the scene may be made so violent as to be ludicrous. The ordinary traffic of a street may be thus speeded up.

Dummies. When a character is required by the plot of the picture to pass through some hazardous experience, such as having his head cut off or falling from a high building, a dummy is substituted.

Means. The action having progressed to the point where the substitution of the dummy is necessary or convenient, the producer cries "Hold it," or "Freeze," and all actors instantly become motionless and remain so, the camera man stops turning, the actor to be *dummied* gets off the scene, the producer and his assistants arrange the dummy figure where the actor was, the camera man is given the signal to turn, the remaining actors are given the signal to go on with the action until it is required to replace the dummy with the actor, when the same plan of freezing over the change is carried on. When the film is developed a short length may be cut out at each of the freezes if need be to improve the picture.

Effects. An accident frequently is a part of the plot of the picture. The dummy substitute may be used to relieve the actor from danger in that scene. The film picture story says that the hero rushes to the rail of an ocean liner in mid-ocean, hurls himself overboard and swims to shore. The picture is made by his rushing to the rail, picking up a dummy of himself and throwing it overboard, while the photographer or producer cuts out that part of the film where he picks up the dummy and lifts it above the rail. The swim to shore and the landing on the distant beach is made in the tank in the studio backyard.

Ghosts. Apparitions are made by exposing the negative film twice before developing it.

Means. A lens with an iris diaphragm so that it may be opened and closed gradually while the camera is running. The full picture having been made, the ghost is staged upon a stage set all in black and the film already exposed is run through the camera again as noted in advance, so many feet with the lens closed, then gradually opening the diaphragm to about one-tenth of a normal exposure continuing for so many feet and gradually closing if the ghost is to fade away, but suddenly capping the lens if the ghost is to vanish instantaneously.

Effects. Only white or light figures may be brought into the picture in this way. The good white fairy may appear thus to wave a signal to the favored hero. A fairy symbol may appear upon the wall of the room and disappear. The actor may lie down to sleep and upon a blank wall (left blank for the purpose in the scene setting) appears the action of his dream.

When the actor thus appearing under the ghost effect is required to take an active part in the play subsequently, or when the figure thus to be produced is not white or substantially so, then the illusion may be made under the plan for dissolving views.

Dissolving Views. When it is desired to have an actor appear in magical manner slowly and to take a part in the action thereafter, the producer causes the actors to freeze, and the camera man reduces his aperture gradually to a closed shutter. The camera man turns his camera back to the point where he began to close, the actor to be produced takes his position and the camera man begins to turn and gradually opens his shutter diaphragm; when the diaphragm is nearly open the action may proceed. Much practice on the part of the camera man, or a special camera with automatic diaphragm is required. Disappearance of any character is effected in the same manner.

Double Printing. Apparitions may be produced by making the two exposures upon separate films and running the two negatives through the printing machine together with the printing stock, so that the images of both the negatives are impressed upon the sensitive print stock.

Where the object to be added to the scene is a dark object to be added in a light area of the original scene, it is added by running the printing stock through the printing machine with the first negative and again with the second negative, separately.

When a satisfactory print has been produced by the double printing process, the print is copied upon another strip of film stock, thus producing a single negative of the double print, from which single negative as many double-printed positives as may be desired may be had, with less trouble than making the total number of double prints.

Double Exposures. The making of ghosts by double exposures has been discussed. An explosion in the midst of a number of men may be made by making an exposure of many feet of film in which at a given signal the men all act upon the cue that the explosion has occurred. The camera man then goes to a black background, having noted the place in the film at which the explosion cue occurred, and runs the film from that point upon an explosion which produces a large amount of white smoke. In the projected picture, the men will be seen enveloped in the smoke of the explosion, which did not occur perhaps until next day. This effect might be made double by printing with the negatives together.

It is desired to photograph the semblance of an actress swimming in deep water, presumably at the bottom of the sea. An aquarium is photographed, or an aquatic background scene is photographed upon the motion film. The actress then is attired in light color, the camera is attached near the ceiling or mounted in the rafters, the actress lies upon the studio floor and simulates the movements of swimming. In the finished picture she is seen swimming among the details of the aquarium or aquatic background scene.

Mirrors. The appearance of a character in a scene may be effected by a mirror upon the stage, the actor standing off the stage but in view of the camera through the mirror at all times, appearing in the picture according to the amount of light which he receives from lamps near him. When lighted he is seen in the play; when darkened, he is not seen.

By mirrors also the effect of diminutive characters upon the stage may be effected. A table is backed by a mirror which is not noted except as a part of the paneled wall. In the mirror is visible an actor who really stands beside the camera. Owing to the greater distance of this reflected actor from the camera, he will appear of shorter stature than those actors who are viewed directly by the camera without reflection. Thus a fairy of diminutive size may be made to appear.

The secret of success in this illusion rests upon the accuracy with which the reflected image is placed in the picture, and upon keeping out of the picture any intermediate objects between the reflected actor and the directly photographed parts of the picture.

Such a picture may be made by double exposure, by double printing, by mirror, or by blackroom methods.

Blackroom. In making a negative of a single figure which is to be printed in with another scene, or in making the second exposure of a double exposure, the stage is hung in black or non-actinic color value.

With a black stage, the distances of all objects on the stage are deprived of their perspective values since all connecting features of the stage are invisible photographically. A man sits at a table near the camera. The camera lens is level with the table top. Upon the distant side of the room a girl is dancing upon a black platform of the height of the table. To the eye of the camera, the dancer's feet just touch the table top, but because of her distance the image is proportionately smaller than that of the man. The resulting picture shows the man sitting at a table upon the top of which is dancing a fairy no more than ten inches tall.

Stop Picture. The dummy picture is called a stop picture because the camera is stopped while the dummy substitution is made. Pictures in which sudden appearances and disappearances are made, are called stop pictures because the camera is stopped while the actors remain frozen. There is another type of stop picture to which the name is particularly applicable, the camera being stopped after every exposure.

Means. A camera making one exposure with one turn of the handle, and which may be left always with its shutter closed by leaving the handle in a latched position.

Effects. By the stop picture it is possible to give inanimate objects the appearance of life. Dolls are made to walk. Toy animals of the "humpty-dumpty" type are made to perform circus feats. Saws are made to cut off boards without hands; hammers are made to drive nails without hands; shoe laces tie themselves, etc.

Method. The stage being set, the handle is turned once on the camera, making one picture, or perhaps several at the beginning before starting the action. The handle being left in its latched position, with the shutter of the lens closed, the moving object of the stage setting is moved slightly. If a box of matches upon a table top is the subject of the picture, the inner box is pushed from the cover a sixteenth of an inch. The handle of the camera is turned once. The inner box is pushed an eighth of an inch; the handle is turned again. The inner box is pushed another eighth and the handle is turned again, the person or the hand which moved the match box having been safely out of the field of the camera before the crank was turned. The box being opened a little farther and a little farther each time soon is far enough open to permit the matches to be extracted. One match raises one end to the edge of the box; the handle is turned once. The match is advanced a sixteenth of an inch and the handle is turned again; another sixteenth, and another, and the handle may be turned several times without moving the match, giving the match the appearance of having paused in its motion to observe whether it is being watched in its escape from the box. Careful study of the extent of each motion of the match and the direction, and the taking occasionally of more than one picture between moves makes it possible to give to an inanimate object a wonderful simulation of life.

This class of stop pictures take unlimited time. Perhaps it is a job for rainy days in the studio.

Film manufacturers are permitting the popularity of trick pictures to decline because of the expense of producing them. The time consumed overbalances all features of apparent economy over ordinary methods for producing the legitimate motion picture.

SCENE FROM "NAPOLEON IN 1814," BY GAUMONT
An Interesting Study of the "Man of Destiny" in His Attitude Toward His Subordinates
Courtesy of the *Kleine Optical Co., Chicago*

WE WILL SELECT THE HOMLIEST ONE

Scene from Photoplay, "Oh You Teacher!"
Courtesy of *Essanay Film Mfg. Co., Chicago*

MOTION-PICTURE THEATER

MANAGEMENT

It is stating a platitude, to say that a motion-picture theater will not operate itself at a profit. If such a condition ever existed, competition and the multiplication of theaters has eliminated it from the ordinary, and has made such instances rare, if not obsolete. Picture theaters from time to time close their doors and go out of business because they do not pay a profit, and others "change hands" because the manager has found that he is making less money operating the theater than he could make doing something else. If the theater would only "operate itself" and pay a profit merely by the condition of its existence, the manager might be a negligible quantity in the picture theater, and his personality, his duties, his special training, and the limitations of his business might be neglected in a book of instruction whose scope is to cover the entire motion-picture industry.

The "Sick" Motion-Picture Theater. A picture theater is giving service to the citizens of a district of the city, conjointly with several other theaters in the neighborhood. Each gets a share of the people who seek entertainment in the evenings in that portion of the city, but one of them, it will be assumed, gets less than the others, while its cost of operation is about the same. It is only a matter of time until the familiar sign "This Place Has Changed Hands" will be seen, the place is closed for a week to emphasize the change of ownership and to advertise the new opening, a few changes are made in the theater, and business is begun again. From this time on, it gets its full share of the neighborhood's theater traffic, or even more.

What is the change? The only fundamental change is the manager. The new manager has brought with him either a knowledge of the motion-picture theater business, or an ability to learn the business while running his theater. The new manager understands from experience or study, or is able to learn and understand, not only his theater itself, but the people, *his people*, his patrons who come to his theater. They are his people, for he makes them his. He studies them, learns them, pleases them, and gets their money.

Several instances of change of ownership have been studied especially for the purpose of setting forth the observations in this book in order that theater managers might profit by them.

Change of Management (*1*). There were three theaters in the same city block, with no other theaters within three city blocks in either direction. The difference in traffic among the theaters in the block was easily noticeable to a motion-picture scout who gave the following two reasons why one of the theaters got less business than its proper share. *First*, it was the oldest of the three and had the least attractive front, each of the later houses having been designed to surpass the older house in outside attractiveness. *Second*, it was at the distant end of the block from a busy cross-street, so that the larger number of people coming to that block reached the other two theaters first, and could reach the oldest theater only by passing the other two.

When the place "changed hands"—an event which came to pass just after the midwinter holidays—the only new element in the theater was the new manager. The place was not even closed for spectacular effect of an "opening night." The new manager, however, was noticed at once. He took upon himself the duties of usher in his theater, and made it a point to stand at the exit door as the patrons who had seen the show came out. If a patron chanced to glance at him, the glance was met with a smile and a remark, "Call again," or "Good night," or "Did you like the show?" or, apologetically, "We are not so crowded except on Saturday nights." He was studying his people as they came out of the theater; he learned them, and they learned to know him and came to expect him to be there. Many of them learned to express praise of a good program which had pleased them particularly, while others by such questions as "When are you going to have another Biograph?" or a compliment upon any specific film picture, told him just what pictures were pleasing *his* people. He began to put out signs of "Good Selig Tonight" and "Repeated by Request," from time to time, and gained for his theater its just share of the business of the block.

Under one manager, this theater failed; under another manager the same theater, unchanged except as to manager, succeeded. The pay roll was the same, the quality of film about the same, the projection about the same; but the manager tried to learn what films would please his people, then obtained that class of subject and from popular factories, and advertised in front of his theater in the particular manner which he found best to attract his passers-by.

Change of Management (2). Of three theaters in two adjacent blocks in a city, one had a front of really artistic design in mission style, finished in the dark stain familiar in mission furniture. This place "changed hands" during the summer. The new manager painted that mission finish a pure white, just like the other two theaters, his competitors. A handsome wall sign at the entrance, containing the announcement of the films, and decorated with miniature electric lights, completed the only changes noticeable as improvements. The "Happy Hour" always had had as good a program as its competitors in the next block, but from this time on it had also just as good a patronage as they.

Change of Management (3). A small "store front" theater in a large city was located on a cross-street near the principal retail business street of the city. The owner and manager lost money all through his lease of a year and at the end of the year was glad to sell his fittings at a sacrifice to relieve himself of the burden of removing them to vacate the building for the owner. The purchaser was an experienced motion-picture theater man, running two theaters on other streets in the same city. He studied the location (before purchasing) and saw that the situation was peculiar.

Because the theater was located on a side street, the crowds of shoppers did not pass its door. Just around the corner, on the main business street for shoppers, were two other picture theaters, taking the trade of the shoppers and leaving the side street theater almost deserted. The experienced theater man saw that this theater location did not have an equal chance to obtain the patronage of the shoppers, but he conceived the idea that there must exist a class of people other than empty-headed shoppers strolling into the first open theater door, and he decided to buy the place, thoroughly renovate it, put in a sloping floor, and make an appeal to a special class of patrons by offering a special class of program.

The old show had been running a program of two reels of film, a new reel and a holdover each day; one song illustrated with lantern slides and changed twice a week, the singer being the pianist; and one vaudeville act. This program was given for five cents. The new manager reduced the size of the picture screen, thereby giving a brighter picture and reducing the jiggle of the picture while still using the same projecting machine. Then the vaudeville act was eliminated and a really good singer was employed. The picture films were changed to a program of "daily change" of the two reels without holdover—for this manager hoped to build up some patronage with office and store people who would come every day, either noon or evening. To this end, his song was changed every day. This gave him a complete change, both pictures and song, every day, with a short program of only about forty to forty-five minutes, but with the quality at the very top, particularly in the matter of the music.

The result was unqualified success, and profit. The difference lay in the training of the manager. The first manager did not understand his environment thoroughly, and tried to run a downtown theater for shoppers on a street where there were no shoppers; the new manager recognized this limitation of location and did not strive to fight against it, but instead reasoned that there must exist in that section a *clientele de luxe*, a class of busy people with an inclination for good music, and who would come every day for a short program of high quality. His success with the theater formerly a failure has proved his wisdom.

Change of Management (4). This theater was one of two, about a block apart, on a business street through a residence district of a city. It was run by a man who owned the store building and who, lacking a tenant, thought it only necessary to put in a theater front and a picture screen and hire an operator and a film service. He did not make his rental value. A young man living in the neighborhood and working downtown during the day offered to take the management of the theater, which was open evenings only. This young man had no experience whatever as manager, but studied the traffic of the neighboring picture show close enough to see that the only difference between the two shows was the quality of the films and projection. He took the management of the house, changed his film service, hired a good projection operator—thereby increasing the running expenses—put out a "changed hands" sign to induce the people to make a trial visit, advertised a special program with hand-bills every week, and got his share of the trade from the first week.

In this case, the first manager made a failure because he did not study his own theater to find out what was the matter with it. The second manager made a success, because he studied the two theaters comparatively to learn wherein the one which he thought of taking was inferior to the competitor, knowing that it was necessary only to equal his competitor to obtain his half of the traffic, and knowing—from a head count and an expense sheet—that half the traffic in his theater would pay him a profit.

Change of Management (5). This case was pure economy in pay roll. One man started a store-front theater and quit before the end of the first winter. The second winter, another man started in the same store, ran it for two winters, and continues to operate it. This picture show is isolated, being in a small town, the only show in the town. The man who ran this show for the first winter knew nothing of the motion-picture business. He furnished a store room with screen and chairs, a piano and a projection machine, hired a pianist, an operator, and a film service, and started the show, acting himself as doorkeeper. The show ran evenings only, and paid no profit. The owner concluded that the town was too small to support a motion-picture theater, and closed the house.

The second manager, who ran the theater the second year, was a projection operator. He did not take in any more nickels than the first manager, but he paid less money to his pianist, he got his film service at a lower figure because he knew what he could afford and did not pay more than it was worth, and, being the projection operator himself, he did not have that expense to deduct from the receipts before calculating his own personal profits from the show business. The net profits to him were such as enabled him to run the show year after year, and to prove that the town would support a motion-picture theater when the theater was run by a manager who understood the limitations of his field and governed his program and his expense sheet accordingly.

Art of the Manager. These illustrations of theaters which have failed under one manager and then have succeeded under another, every one with only some small difference in paint, or program, or pay roll, are given to illustrate the statement that in many if not nearly all cases the element of success or failure lies with the manager.

Every one of the instances show merely that the new manager adapted his theater to the conditions which he found existing as limitations upon the theater when he took charge of it.

In the example (1), the new manager decided to make his theater different from his competitors by learning the particular things which would please his people and by giving them a personal courteous attention. He won success.

In the example (2), the new manager decided that his theater was as good as his competitor's except that it had a sober front, almost repellent to the joy seeker. He changed the color of the front, and won success by eliminating his theater's handicap.

In the example (3), the new manager decided that an ordinary theater could not be run successfully in that location, so he tried an extraordinary program, and won success.

In the example (4), the new manager decided that his theater had only one handicap over his competitor, the quality of films and projection. He removed this fault, and won success.

In the example (5), the new manager saw that the expense could be reduced even though the receipts could not be increased, and his profit lay in the difference. Notice that he did not give a poorer program, but gave the same quantity and quality program at a smaller expense.

In (2) and (4), the new manager found a single feature in which his theater was behind his competitors; he brought that feature up to his competitors and won his share of the business.

In (1), in (3), and in (5), the location of the theater was not good, but each of the managers found a different solution; in (5), it was simple economy; in (1), it was personal attention to the likes and dislikes of his patrons; in (3), it was a Napoleonic stroke of generalship.

Reviving a "Sick" Picture Theater. There is only one symptom which attracts attention to the disease of the theater, and that is the lack of satisfactory net profit. This symptom may be due to either of two diseases: *first*, that the income is not large enough; and *second*,

SCENE FROM PHOTOPLAY, "THE LAST APPEAL"
Courtesy of *Independent Moving Pictures Co., New York*

LEONORA BEGS TO BE PERMITTED TO SEE MANRICO
Scene from Pathé film, "Il Trovatore"
Courtesy of *Pathé Frères, New York and Paris*

that the expense is too large. In example (5), the new manager did not think the income could be increased, but he reduced the expense. In examples (1), (2), and (3), the new manager did not decrease the expense, but by his skill he increased the income. In example (4), the new manager found both income and expense too low, and increased both, increasing the income more than the expense.

The "sick" picture theater must be studied particularly with reference to its competition and its location. Then the traffic of the community must be studied to learn whether there is sufficient traffic to support the theater. The question of traffic may be studied in two phases: *first*, whether there is enough to support the "sick" theater if it were to get its proportion of the total; and *second*, whether it is necessary or advisable to try to surpass competition and secure for the "sick" theater more than its proportion. The second proposition is a case for a doctor of experience.

Competition. Study every point of difference which can be found between the theater in question and its competitor or competitors: The color of the front; the decorations of the front; the announcement signs for number, attractiveness, and general desirability; the poster service used for the films; the style of ticket window; the courtesy of the cashier; the method of taking the tickets at the door and the courtesy of the doorkeeper; the seat arrangement; the width of aisles and the confusion or convenience of incoming and outgoing patrons when the place is handling a crowd; the comfort of the seats, their style, their width, and the space between the rows, whether cramped or liberal to permit passing an occupied seat; the number of seats; the decoration of the walls; the illumination during the pictures and during the intermissions; the quality of the films, whether new or old and whether clean or dirty or scratchy; the quality of the projection, whether dim or brilliant, whether steady in light or full of flicker, whether steady in position or full of jumps and jiggles on the screen, and whether the whole picture on the screen rises and falls with a wave-like motion; the quality of the song slides and their projection; the quality of the singer; the music or entertainment during intermissions in the program; the character of the vaudeville, and whether it suits the audience or displeases them, being endured only for the remainder of the program; the frequency of change of program, pictures, songs, and vaudeville.

When a point of difference is found, study it to see whether the difference is to the advantage of the theater under study or whether it is to the advantage of the competitor. Then decide whether any change should be made in the theater studied.

The result of this study should determine whether it is possible at a reasonable expense to bring the theater studied up to equality with its neighbors, and the study should permit the making of an expense sheet for running the theater in equality with its neighbors. The new expense sheet may be smaller or larger than the old; that is immaterial, for the question is: "What will be the expense of making this theater equal to its neighbors or competitors that it may divide the trade with them?"

Traffic. An actual "head count" of the patronage of the neighboring or competing theaters must be made, and a count of the number of people "held out" during the heavier hours of traffic, if such occurs. Add the total of all admissions for the theater studied and its competitors, and divide by the number of theaters for the hours of lighter traffic and divide by the number of seats in the capacity of the houses for the hours of heavier traffic when patrons are being held out at the door. This will give the revenue to be expected in the theater studied if it were brought up to quality with its competitors.

Income vs. Expense. The two amounts thus obtained—the income from the ticket window and the expense account for equaling competition—will give the profit of the theater without consideration for side lines of profit.

The ticket-window profit may be increased by a judicious use of side lines for profit, unless the matter of such devices has been abused and thus brought into disrepute in the neighborhood.

The side lines which may be considered are: (*1*) paid advertising on a drop curtain, displayed during intermissions; (*2*) paid advertising slides for the stereopticon; (*3*) paid advertising space on printed programs handed to the patrons either on entering or leaving the theater; (*4*) paid advertising on hand-bills containing theater announcements and distributed through the neighborhood; (*5*) sales of candy in the theater during the intermissions; (*6*) control or co-operation of a confectionery and refreshment business adjacent to the theater; (*7*) automatic slot vending machines.

Managing a Theater for Profit. Continuous study of the theater, day by day and week by week, comparing it with its competitors and comparing it with other theaters at a distance but similarly located, similarly surrounded, and similarly equipped, will enable the manager to determine just what his theater ought to do in the way of gross receipts, expense, and net profits. This gives him a theoretical result which should be attained by his account books. If his books do not show the amount of profit, and from the different sources, which his study shows, he should study his theater as a "sick theater" and strive to learn why he is not doing as well as his competitors, or as well as some other theater operated by another manager under comparatively the same conditions. A study of other theaters, near and far, a study of the technical papers, and a study of the advertising and educational matter constantly sent out by manufacturers in the motion-picture industry, films, machines, accessories, and sundries, will give the manager a correct idea of what his theater should accomplish. Then he may study his own house to learn whether it accomplishes what it should, and if not, he may learn by still further study what is lacking that prevents it from attaining daily its just deserts and its maximum profits.

STARTING A THEATER

The first detail is to choose a location, then to decide how extensive an investment the location will justify because of its prospective patronage. After that, the building and operating of the theater becomes routine detail, the theater succeeding or failing according to the ability of the manager, his attention to the details of the theater and its patronage, and his ability to learn and understand the salient facts in his studies.

Selecting a Location. *Among Competitors.* In this case, the proposed location may be studied as though the site were already occupied with a "sick theater." The traffic upon the existing theaters may be tallied up and expressed in dollars per week; then a reasonable increase may be figured, for a new theater added to the ones already existing will increase the total of the traffic. This total may be divided to learn how much money will be taken at the ticket window of the proposed new house. Side lines for profit then are studied and added, the total income and the total expense are obtained and compared, and the answer is obtained to the question: How much will another theater in this locality pay in profits?

This study may be made upon the basis of another small store-front theater competing with one or two already established, or it may be made upon the basis of constructing a larger theater. If a larger theater is to be compared with a store-front competitor, the total traffic may be increased largely, say doubled, for the larger, more pretentious house will draw traffic over a larger area, for a greater distance both ways on the street, and then in turn will take a larger share as its proportion of the total, particularly in view of larger seating capacity on the rush evenings when all houses are holding the patrons out for want of seating capacity.

New Territory. The only difference is that the traffic to be expected is more indefinite in calculation. It may be predicted very closely by a "head count" of the people passing a possible location. The count should be made every evening for a week, or during all such hours of the week as the theater would be open for business. In the absence of other data, this number may be divided by ten to obtain the number of nickels which may be expected, or one-half cent for each person passing the possible theater. Towns vary in this respect. To obtain the proper figure for the town in which the possible theater is being studied, go to other theaters in the town, count for a few evenings the number of people passing the theater and the number of people passing into the theater, and learn whether the theater gets one out of eight, or one out of twelve, or one out of twenty who pass the door. To the casual mind, the following law may seem without reason, but it will hold true: *The proportion of people who pass into an ordinary picture theater to the people who pass by will be about the same in all parts of the same city, and the patronage of a theater in open territory may be predicted from a count of passers at the site where it is proposed to start the theater.*

Having thus by "head count" obtained a figure for the ticket window receipts, the expenditure for establishing the theater, and the pay roll for operating it may be determined in advance, and a theater may be built in that location which will pay a reasonable profit on its investment and running expenses—in short, a successful theater may be established, because it will be established in harmony with the possibilities of its location and environment.

A person looking for a theater location will find many "possible" places where he might rent or build and start his theater. All of these, or at least several of the more promising of them, should be studied carefully and in detail, making up an income and expense account for each of the locations; then the best may be selected and the theater started.

Small Town. This is a case for study, not so much to determine the place in the town where the theater should be located, but to determine whether the town itself is a suitable location for a theater, whether it will support a theater and how much of an investment and pay roll will be justified.

The "head count" for a town so small that only one theater is possible may be taken from the census reports. Any town of 1,000 people will support a motion-picture theater if it is run by the right man and in the right way. It is found that a "one theater" town will pay weekly at the ticket window from two and one-half to five cents per capita on its census population. A town of 1,000 people will yield from $25 to $50 per week on a show running six nights per week and Saturday afternoon or whatever day of the week the country people use for market day, usually Saturday, but not always.

The gross revenue of the small town being determined by multiplying the census population by a reasonable amount to be expected, say three and one-half or four cents per week, it remains for the prospective theater manager and owner to decide whether he can bring his expense sheet sufficiently below the gross receipts to leave an acceptable profit for his time and whether with such an expense sheet he can give an acceptable show which will continue to bring the money after the first few weeks, when the novelty of the theater has worn away.

The manager must make himself thoroughly familiar with any city ordinances regulating the operation of motion-picture theaters. Even small towns are having such laws enacted.

Financing. For the man who believes that he can make money in managing a picture theater, whether he has experience in the picture theater business or not, yet who has not the necessary funds for starting it, there occurs the problem of securing the money, and upon such terms as will yield him a profit and not pass all the profits to the capitalist who furnishes the money and does no work.

For a small enterprise, which will not require more than, say $2,000, with anticipated profits (excluding manager) of $50 to $75 per week, the manager and promoter may profitably arrange to "split the profits" with the capitalist. This will yield the manager a revenue of $25 to $37.50 per week if he can run the theater according to his expectations, while the capitalist, who is sole owner of the theater under the agreement, will receive a liberal return on his investment, even allowing for depreciation of the theater fittings.

For a larger enterprise involving much more capital the capitalist may insist upon an unequal division of profits, because the anticipated salary for the manager and promoter would look large. In such an instance, the manager should insist upon a fixed salary for himself carried as a part of the expense pay roll of the theater; and in addition an unequal division of the net profits, giving the capitalist the greater portion.

For any enterprise where more than one man puts up any money, a form of stock company or partnership agreement should be drawn up and signed by all. This cannot be much more than informal unless placed in the hands of an attorney-at-law for proper form, but in any event it should be a signed agreement. In such a financing plan, the manager operating the theater will receive a salary as a theater expense, and all profits will be divided by the partners or stockholders in proportion to the amounts of money each of them furnished. A share of the net profits is provided for the manager and promoter by giving him a share in the ownership which he earns by his work in organizing the company instead of by paying cash. This may be one-tenth to one-half stock interest or ownership.

A Store-Front City Theater Building. A vacant business house having been selected both for location and for size, the process of converting it into a motion-picture theater is to remove the glass front and framing for the door and window, to replace it with a closed front a few feet back from the sidewalk line into which are built the ticket seller's booth and the entrance and exit doors and on the inside of which is built the projection operator's booth. At the inner end of the room a muslin screen about 3 by 4 yards is stretched. The room is filled with rows of chairs, either kitchen chairs or opera chairs, as the expense justified by the location will permit, and a piano is placed near the picture screen.

Floor Plan. A few general rules which may be followed in floor-plan construction are given herewith; aside from these a large variation in floor plan is possible.

The projecting machine should be at one end of the room and the picture screen at the other end, both being so high above the floor that the rays of light from the projecting machine to the lower edge of the screen will not be interrupted by patrons passing down the aisle.

The front of the room must be closed against the lights of the street, even when a patron is entering.

The operator's room must be laid out with reference to comfort and convenience, 6 feet square is a desirable smaller limit.

The floor space, if limited, must be laid out to seat as many people as possible, up to the number which the traffic study will require.

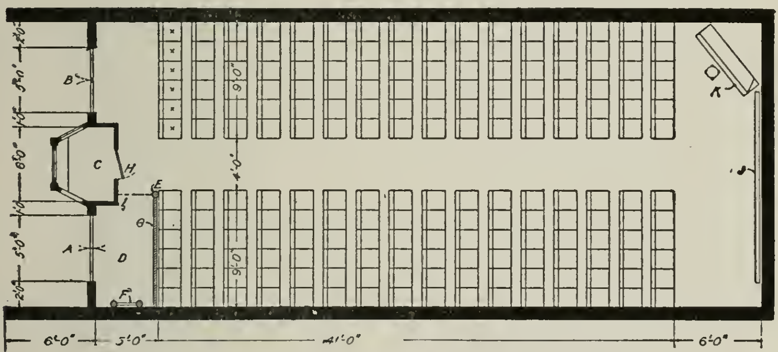


Fig. 1. Floor Plan for a Small Store-Front Theater

The operator's booth must be lined with sheet iron, top, bottom, and sides, with a door having a latch, and with two look-out holes, one for the beam of light from the lenses and another at least a foot square and with the center at the height of the operator's eye, through which the operator may look to see his picture on the screen; these requirements are for protection against fire.

A floor plan which is adaptable to the general requirements of any store-front theater is given in Fig. 1. This shows an arrangement for the maximum seating capacity for a store room 22 feet by 58 feet inside the walls. The seating capacity shown is 192. The front partition of the theater is placed 6 feet back from the sidewalk. The ticket booth extends forward from this partition. A still deeper front is desirable if the floor space can be spared; it gives advertising space;

it gives opportunity for decorative efforts without the expense of decorating the entire front of the business house; it suggests retirement in the theater, and when the prospective patron steps off the sidewalk he feels that he is already within the theater, even before he has purchased his admission ticket.

The entrance and exit doors in the partition should be double doors. The entrance doors at *A* should swing both ways, while the exit doors at *B* should swing outward but not inward.

The ticket booth in Fig. 1 is 6 feet by 5 feet inside, with a shelf 1 foot wide across the front for making change. The three glass windows should be made with removable sash in order that screen wire or grille may be substituted in the warm weather.

The operating booth occupying the upper part of the space *D* is built over the ticket booth upon an elevated platform about 5 by 9 feet in size. As the patrons of the theater are required to pass under this platform it should be built upon a platform about 7 feet from the floor. A stanchion is set from floor to ceiling at *E*, about 9 feet from the side wall and 5 feet from the partition, and with this stanchion as a corner post a platform is built to cover the space *D*, then closed in with walls from the platform to the ceiling to form the operating room. Windows for projection and lookout are left in the wall toward the screen *J*, and another window may be left in the end for ventilation and over the doors *A* in the partition. Entrance to the operating room is obtained by means of the ladder at *F*, which extends upward along the wall and through a hole about 30 inches square in the floor of the operating room.

Below the operating-room platform, extending from the stanchion *E* to the wall, a screen *G* should be placed to prevent the light of the street from reaching the screen when the doors *A* are open; this may be a curtain hung from the edge of the operator's booth. The doorkeeper stands at the post marked *H*. A movable chain or bar is provided to extend from the stanchion *E* to the wall of the ticket booth to close the passage at the dotted line *I*. This enables the doorkeeper to hold back patrons who come so near the close of a picture or act that they would be interfered with by patrons passing out, or by patrons for whom there is no seat.

The piano may be at *K*, either automatic or manual. The screen *J* is shown at one side of the center; this has two advantages in the floor plan as shown. It gives more room for the piano and singer at the side of the screen, and it brings the center of the screen nearer to the direct line from the projection machine at the end *I* of the operating room at *D*.

Another method of building an operating room is to build it over the cashier's booth, extending through the partition and projecting into the theater room as far as the stanchion *E*. Set two stanchions like *E* and build the platform to the ceiling, placing the ladder *F* beside the short wall of the cashier ticket seller's booth, just inside the entrance door. The projecting machine will stand against the wall of the operating room at the exit-door side, and the projection and look-out windows should be placed in the front wall accordingly.

A space of 6 or 8 feet between the front chairs and the picture screen should be allowed, as the pictures cannot be viewed at a very close range. If the seats marked *X* are left out, the added convenience to patrons in passing out of the theater may more than compensate for the decreased seating capacity.

Lighting Methods. Ceiling lights, say a sixteen-candle-power lamp for each 50 square feet of floor, should burn during the intermissions. Shaded wall lamps, say an eight-candle-power lamp every 10 or 12 feet along each wall, should burn all the time, including the time during the pictures. The wall lamps should be so shaded that the light will not shine upon the picture screen nor upon the eyes of the audience.

The term "daylight-theater" is used to designate a theater in which the auditorium lights are not turned off during the projection of the pictures. This result is attained by hanging the ceiling lamps in sixty-degree conical shades, or the equivalent in ornamental shades, so that the light from each ceiling lamp covers a circle on the floor under the lamp but does not shine on the picture screen, nor does it shine back toward the entrance into the eyes of the seated patrons. The lamps thus shaded must be distributed over the theater ceiling, and not grouped, as then the desired effect would be lost.

Low-Cost Store Front. To build for the lowest cost of starting operation, in a location where only the minimum expense is justified or where only the minimum expense is desired, the front partition may be modeled upon the style shown in Fig. 2. This is all simple carpenter work and painter work. The complete change in the store room, ready for chairs, piano, wiring and projecting machine, should not exceed $150; 200 chairs of the kitchen variety at $100; electric lamps and wiring at $100; a projecting machine at $165; and a rented piano—the total expense amounting to about $500. With a small additional amount for supplies and initial advertising expense, the manager will be able to open his doors to the public at a total cash expense of not more than $600, and no debts.

Only country towns of small size without competition, or un-

Fig. 2. A Simple Front Design for a Store-Front Theater

occupied or non-competitive city territory, will permit a successful theater with so simple an establishment.

Such a theater could be established upon a prospective ticket sale of $110 to $150 per week, since the return for the manager's labor and a return for the cash invested must be earned in addition to the expense sheet given below. The item of "Supplies" includes tickets, carbons, condensers, lamp renewals, machine repair parts etc., and piano tuning, including in this case also the rent of the piano. This is a fair expense account for a small city house, even though at a much larger initial cost, where competition does not compel a larger expense, yet where the patrons constantly are comparing this residence district theater with the more pretentious down-town motion-picture theaters. With such distant competition for comparison, it is necessary to maintain a quality of picture projection and music which will stand the comparison, if the theater is to be a continued business with profits.

The cost of operating this theater, evenings only—for it would be either in a small town or in a residence territory of a city—for a program of two reels of film and a song, would be, by the week, about as follows:

Rent and heat	$ 10.00
Electricity	5.00
Film	20.00
Song Slides	2.00
Supplies	13.00
Operator	15.00
Cashier	3.00
Doorkeeper	5.00
Pianist	5.00
Singer	5.00
Weekly Expense	$ 83.00

In a non-competitive small city, not only will the rent be lower, but the wage rate will be lower throughout.

Elaborate Store-Front. The floor plan will be the same in this case as in Fig. 1, the difference being found in the quality and appearance of the elements going to make up the theater.

A decorative front such as is illustrated in Fig. 3 will cost $500 to $2,000 for the front partition complete with operating room and cashier's booth, including all the decoration in front of the partition. Another $500 or more will be needed to raise the floor and to install 200 opera chairs at $1.20 to $1.60 each. The inside decorations and the picture screen of modern type will raise the expense $200 to $300 at least. The total expense need not exceed $6,000; with any pretensions toward beauty and luxury, it cannot be kept below $2,000.

For designing and building the front, a firm in the special work should be employed, unless the manager who is starting the theater is of long experience and knows exactly what he wants. The large number of such theaters which have been built has developed construction firms and workmen particularly skilled in such work, whose very presence on the job will insure that refinement and perfection of detail which the manager desires but which the inexperienced

Fig. 3. A Decorative Front Design for Store-Front Theater.

manager employing inexperienced workmen is likely to overlook, leaving his house inferior to those of his competitors.

In selecting or approving a plan by a professional designer, the manager should see that the cashier's booth is large enough for comfort all the year round and that the projection operator's booth is large enough for two operators and two projecting machines. Not only may competition enforce the employment of two operators, but it will be found positive economy to give the operator an assistant during the rush hours of Saturday night.

In a house of this class, a manager's control panel and signal system should be installed at the door where the ticket-taker stands, that he may signal the operator to begin projection, and may ring for the singer, etc., controlling the conduct of the program particularly during the rush hours when the passing of numbers of people in or out may delay the beginning of the next picture.

The program selected—by this term "program" is included the quality as well as quantity of pictures, song, music, and vaudeville—must follow the custom of the city in which the theater is located, if the certainty of a proper division of patronage is desired. A departure from the custom of the city may result in a larger success, or may result in failure. Such a departure was made in the theater discussed in "Change of Management (3)," and serves as an example.

A specimen expense sheet of a high-class store-front picture theater is here given.

WEEKLY EXPENSE SHEET

Rent, of complete theater, week.....	$ 40.00
Film rent, three reels daily change...	50.00
Carbons..........................	1.00
Pianist..........................	15.00
Violinist........................	10.00
Drummer..........................	12.00
Usher............................	2.50
Electricity......................	18.00
Song Slides......................	2.00
Cashier..........................	5.00
Singer...........................	18.00
License..........................	4.00
Projection operator..............	18.00
Porter...........................	4.00
Ticket taker.....................	5.00
General Expense..................	10.00
Total weekly expense, not including manager......................	$214.50

Receipts, average, six nights $240, Sunday $100; total weekly receipts, average, $340.

Specimen Expense Sheet of a High-Class Store-Front Picture Theater. The figures given above are the actual expense sheet of a house of this class in a residence district of Chicago. The rent item is the amount paid per week, making a rental of $173 per month or $2,080 per year, but this is for the house equipped with chairs and projecting machine, so that the expense sheet is carrying the item of depreciation of investment as a part of the rent item. The cost of opening this house for business was in the neighborhood of $3,000.

This particular theater charges a five-cent admission seven days in the week. The seating capacity is 300. A one-hour program is given at 7, 8, 9, and 10 P.M. on week days and at 2, 3, 4, 5, 6, 7, 8, 9, 10 P.M. on Sundays—thirty-three shows per week, three reels and a song in each program. The film is one reel third-run, one reel not more than ten days old, and one reel not more than three months old, daily change, for which $50 per week is paid. Two different songs are given, alternating in every other program, with one singer. Music is furnished by an orchestra of three. The item of "Sundry Expense" includes tickets, coal, condensers, poster service, machine repairs, lamp renewals, piano tuning, etc.

In this theater, the manager takes profits rather than a salary. He has no capital invested, but in the $40 per week rent he is paying a return to the capitalist for the investment.

Sloping Floor. This method of floor construction raises the eyes of patrons in the back seats above the heads in the front rows, giving the patrons at the back of the house a better view of the picture screen or stage. The sloping-floor construction is necessary in houses classing above the simplest of store-front theaters. It is a good bid for business to equal or excel a competitor, because it gives a greater comfort to the patron, and makes the picture theater resemble more closely the larger, more pretentious city houses.

A side view of a store-front theater with one wall removed is shown in Fig. 4. This shows the sloping floor, and one method of constructing it for store-front houses. Where the building is erected specially for theater purposes, even though it be a part of a business block and a store-front in appearance, this plan is easily followed, but where an old building is remodeled it is necessary to cut the floor joists at the picture screen end if the entrance doors are to be level with the street or sidewalk.

A raised floor may be constructed upon the store-room floor by building a few low trestles or "horses" across the house, say 18 inches or 2 feet high at the street partition of the house, and getting lower toward the picture screen. Joists for the inclined floor are laid sloping upon these trestles, and taper to a point at the toe where the new sloping floor meets the old level floor. The slope may extend two-thirds the way to the picture screen, and the front third of the house may be level.

Steps may be built between the street level and the raised floor, or the floor may be sloped up from the street line to avoid steps, even carrying a slope into the aisle of the theater.

The floor plan arrangement for the street end of the theater of Fig. 1 is suitable for the theater of Fig. 4, or the projection booth may be built over the ticket booth.

In the theater of Fig. 4, the requirement for the height of the projection room floor and for the height of the projection window is that *the rays of light from the lens to the lower edge of the picture screen should clear the heads of persons standing in the aisle.*

A comfortable amount of slope for the theater floor is 1 foot in 8. This is the slope shown in Fig. 4.

Seats upon a sloping floor must be the "*theater seat*," as shown in end view in Fig. 4; or if chairs the legs must be sawed to make

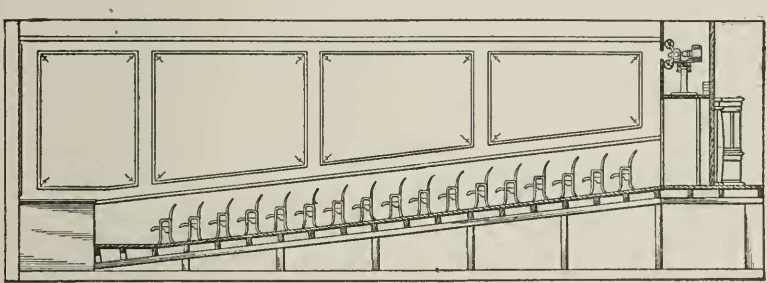


Fig. 4. Theater with Sloping Floor

the chair comfortable. When theater seats are bought, it should be specified that they are for use upon a sloping floor, and they will be furnished accordingly by the manufacturer. The seats between the bottom of the slope and the picture screen are ordered for level floor.

Stage. If a stage is to be built, either for vaudeville purposes, or for scenic effect in the theater, the stage floor should be 3 feet above the theater floor in front of the stage. The proscenium arch in such a stage may extend to within 1 foot of a low ceiling, and within 3 feet of each side wall.

If for decorative effect only, the picture screen may be stretched permanently across the opening. The projected picture should be kept a foot or two above the bottom of the screen.

If for use for vaudeville, the stage should be 10 or 12 feet deep, with two wings on each side. An interior flat should be at the back and a street scene half-way between the back flat and the drop curtain. The picture screen should be at the front, just behind the drop curtain. By "interior flat" is meant a flat painted scene showing the interior of a room. There may be two pairs of wings for the interior scene setting and one pair of wings for the street scene, with flies sufficient to conceal the ceiling from the patrons in the front row of chairs.

If the stage is used for vaudeville, footlights must be installed, with switch at the ticket-taker's station at the entrance, and the projection operator must be provided with a mask for his stereopticon which will cover the stage opening but not the sides of the arch.

Picture Screen. For a screen against a wall, the wall may be painted white, or given a "white finish" coat, such as plasterers use in finishing a wall smooth. Over this white surface, stretch a sheet of thin muslin, with as few seams as possible. Have the seams run horizontally, and tack the muslin all around the edges. A neat and inexpensive finish is obtained by nailing to the wall a frame of wide picture-molding, mitering the corners as though the screen were framed and hung upon the wall.

Any wall screen or drop curtain screen may be treated by a coat of paint containing finely divided particles of some glittering substance, such as finely-divided aluminum dust, or finely-powdered glass, or the curtain may be painted with any sticky paint and the metallic dust or powdered glass thrown or blown upon it and, when the sticky paint dries, a glittering surface will remain upon the screen producing what is known as the *metal-surfaced* screen. These tricks of producing metal surfaces are well known by sign painters.

The picture projected upon such a *metallic-surfaced screen* is more brilliant in its light portions, while retaining all the detail of its darker or shadowy portions. At the same time, the dead white screen may be a matter of personal preference, or where all competitors use a metallic surface, the dead white of thin cloth backed by white plaster cleaned from dust occasionally to keep it white,

TRAVIS' LAST STAND IN THE ALAMO
Scene from Photoplay, "The Immortal Alamo"
Courtesy of *G. Melies Company, New York*

HARVEY BARTON AND HIS SWEETHEART, KATE BOWERS
Scene from Photoplay, "The Puncher's New Love"
Courtesy of *Essanay Film Mfg. Co., Chicago*

and kept free from stains at all times, together with a smaller and brighter picture, may be urged as an advertising point of advantage over the methods of competitors.

The *mirror screen* increases the brilliancy of a picture. Also, it is likely to give "haloes" or radiant bright spots to some places of the auditorium if the surfacing is not sufficiently dense. The cost runs to $300 or $400.

The theoretical mirror screen as announced to the public consists of a sheet of plate glass, the size of the projected picture; this glass is silvered upon the back and ground to a smooth ground-glass finish upon the front surface. The ground-glass surface gives a good screen surface for projection, even if not backed, being equivalent to a surface of finely-powdered glass, but all light which passes through the ground-glass surface is reflected by the mirror back to the surface again and through it to the spectators in the theater. The result is a large increase in brilliancy in the picture projected with the same conditions of lamp and lenses.

Mirror screens are made also by painting the surface of a large mirror with a frosting surface, such as a thin mixture of English "whiting" with water and a little glue. A substitute for the real mirror screen is a mirror over which is stretched a sheet of thin muslin. The muslin should be seamless—muslin sheeting 8 feet wide may be obtained in the market—or the seams must be made by setting the two selvedged edges against each other and whipping them together with a very fine stitch without lapping the fabric. Where a lap seam is used, the mirror behind the fabric shows the seam so very plainly that it becomes decidedly objectionable.

The thin fabric screen backed by a mirror is an improvement upon the fabric screen backed by a white wall. The cheapness of such an arrangement is based on the fact that the mirror used to back such a fabric screen may be made economically of small sheets of silvered glass rather than of a single large sheet, the small sheets being set snugly together without bevel edges and without mounting, that the lines of joining may not be noticed by the patrons. Small clamps may hold the mirrors to a supporting wall or vertical platform, care being taken to make the entire mirror surface flat.

Where, because of clearing the stage for vaudeville acts, it is necessary to roll the picture screen, the screen must be made of opaque white fabric, and fitted with a heavy roller to stretch it when rolled down, or tackle must be used at the bottom to stretch it. A waving curtain produces a very objectionable effect in the picture. Metallic surfaces have been used on *roller picture screens.* Great care must be used to avoid wrinkles when the metallic surface is used, for the small wrinkles are much emphasized by the reflecting nature of the sparkling surface.

Special Buildings. A theater building having a 50-foot front and seating five hundred or more people may be built at a cost aside from the lot of $10,000 to $20,000, according to design and location. Such houses usually are run to a longer program than an hour of pictures, being vaudeville houses rather than simple picture houses.

The principles of operating such a house do not vary from those of the smaller picture theaters. The same tact, skill, and ability to learn from experience and from observation of other houses of the class are required of the manager. The same balancing of gross income against expense, and the same possibilities of side lines for additional profits, exist.

A house of this size in the residence districts usually runs a vaudeville program and charges an admission of ten cents or more.

Example of Special Theater Building. The class of theater occupying a specially constructed building, in the residence districts of Chicago, is well represented by the particular theater from which the following facts are taken:

The lot, 50 by 125 feet, upon which the building is erected, was estimated in value at $10,000; and the erection of the building and its equipment ready for the public, cost $15,000, making a total expense in the building itself of $25,000. For this investment the owner takes a rental of $5,200 per year from the receipts of the theater. This item is considered an item of rent in the theater expense sheet, and is paid weekly at the rate of $100 per week, as rent.

The program consists of four acts of vaudeville, two reels of film, and a song. There is an orchestra of four pieces. The program lasts about an hour and a half to an hour and three-quarters. The program is given twice each night, once on Wednesday afternoon, once on Saturday afternoon, and twice on Sunday afternoon; eighteen performances per week, of which four are on Sunday. In case of a long vaudeville program, the song is omitted.

The house contains 800 seats, of which 600 are on the main floor and 200 on the balcony. Of these, 350 seats are sold at twenty cents and 450 at ten cents; the total value of a full house is $115. An average evening in fair weather is a house and a half for the two performances. Of the twenty-cent seats, fifty are the front rows of the balcony; this raises the tone of the balcony as a seat location and helps to sell the house out when nearly full.

The film service is one reel ten days old and one reel not more than three months old, change twice a week; for this service, the price paid is $20 per week. The entire program, vaudeville and film and song, is changed twice each week.

The illustrated song slides, when used, and the singer as well, are furnished free by the music publishers for the advertising value.

WEEKLY EXPENSE OF A SMALL VAUDEVILLE THEATER

Rent, per week	$100.00
Film service, per week	20.00
Carbons	1.00
Orchestra of four pieces, per week	91.00
Two ushers	5.00
One fire guard	7.00
One stage manager	20.00
One stage helper	7.00
Electricity, per week	30.00
Cashier	7.00
License	4.00
Poster title service	5.00
Projection operator	18.00
Vaudeville, average weekly	500.00
Porter and watchman	12.00
Ticket taker	8.00
Sundry small expenses, average per week	25.00
Weekly expense sheet	$860.00

Average receipts for six days, fourteen performances, $900.00; for Sunday, four performances, $315. Average weekly receipts, $1,215.

Large Exclusive Picture House. Only in the shopping district of a city can a sufficient number of patrons be found to fill a large house repeatedly for short programs. The data given here for such a theater is taken from a theater on the busiest retail business street of one of the largest cities of the United States, a theater representative of the highest class of motion-picture theater.

The house is open fourteen hours per day, seven days each week, from 9 A. M. until 11 P. M. The program is three reels of film (or three pictures, not necessarily each a full reel) and two illustrated songs. The film is all first run, changing the three reels three times each week, without holdovers, but a good film picture frequently will be repeated a few weeks later, with the advertising sign, "Repeated by request." The songs are changed weekly. Two singers are employed for the two songs of each program, one male voice and one female voice.

Three projection operators, working at the same time in the operating room, put on the program. Two of these operators have motion-picture projecting machines, while the third operator projects nothing but stereopticon slides, both announcement slides and song slides, attending also to the illumination of the auditorium during the intermission.

The order of the program is as follows: The show starts with a few announcement slides; then the first motion-picture operator puts on the first film picture. As the end of the film picture approaches the stereopticon operator stands ready and projects the song title upon the tailpiece of the film, the pianist opens the introduction to the song as the title appears and the song follows without a second of lost time. At the close of the song, the second motion-picture operator stands ready and begins projection at a signal from the stereopticon operator, the last slide of the song dissolving into the title of the next film picture. In the same manner the screen continues without interruption of projection into the second song and then into the third film picture by the first projection operator. At the close of the third film picture the lights are turned on, the crowd is allowed a few minutes for passing out and in, the candy man makes a trip, and the program is repeated. The house is "dark" about fifty minutes for the program of three pictures and two songs, and is "light" for about five minutes for the intermission.

For the ordinary day, fifteen performances are given in the fourteen hours. On Saturday, the busy day, an extra performance is given, making sixteen in all.

The house, equipped fully for the operation of the theater, represents an invested capital of $160,000. The building was completely remodeled for the theater, under lease to the theater managers. It is not owned by the theater managers, and a rental of $48,000 per year is paid. This includes heating. Figured upon a weekly basis for the weekly expense sheet, this rental is $923 per week.

The theater seats seven hundred people. The admission price is ten cents, anywhere in the house, giving a value for a "full house" of $70.

The attendance averages about six-tenths of the total capacity

—six-tenths of seven hundred seats, filled fifteen times on an average for six days, 6,300 tickets per day for six days and 400 more on Saturday for the extra performance, about 44,500 tickets per week, or $4,450 weekly receipts at the ticket window. On many Saturdays —the busy day with sixteen performances—the ticket sale reaches nearly 10,000, or $1,000.

The theater is operated by two sets of employes, called the day force and the night force, each working seven hours continuously. The day force works from 9 A. M. until 4 P. M., the night force then coming on and working until 11 P. M. Thirty-five employes are on the pay roll of the theater itself, aside from the manager and his clerical help.

The orchestra comprises pianist and drummer, and a "sound effect" man for adding something of realism to the pictures by supplying some of the sounds attendant in nature upon the scene represented.

WEEKLY EXPENSE. The item of rent is a matter fixed by contract with the owner of the building. It appears high when compared with rental values of theaters of similar seating capacity but located in the residence districts of the city where the land values are not so high.

In the item of electric current, it must be noted that this theater runs fourteen hours per day, against an average of five hours per day for a residence district theater. The electric lighting and electric signs in front of the theater are profuse, and most of the lamps burn the full fourteen hours per day that the theater is open.

The film rental item of $126 per week for three reels changed three times a week takes into account the large number of times that each reel is run through the projecting machine. The wear upon the film naturally is greater for the fifteen shows per day which this theater gives than it would be in a residence district show of four performances daily. It is true further that "first run" film is the most expensive run of film for the theater manager to buy, and that all of this theater's film is first run film.

The item of "sundry expenses" includes tickets, carbons, lamp renewals, machine repairs and depreciation, piano tuning, painting a large sign three times per week with each change of program, and many minor expenses.

In each of the items where the pay roll is involved, it is remembered that the item is doubled to provide for the two forces of employes covered by the list, the day force and the night force.

Six projection operators are employed, three for the day force and three for the night force; of each set of three, are two motion operators and one slide operator.

A guard in full police uniform is in attendance at the entrance door. A fire guard is required by the rules of the fire department of the city.

The orchestra of six employes comprises the two pianists, the two drummers, and the two sound artists.

Of the four singers, each is required to sing seven or eight times—a day's work. Two are on the day force and two on the night force; each sings once in each show.

WEEKLY EXPENSE SHEET

Rent and heat, per week	$923.00
Electricity, per week	200.00
Film rental	126.00
Song slides	2.00
Sundry expenses, per week	130.00
License	8.00
6 Projection operators	112.00
2 Cashiers	30.00
2 Uniformed police at door	36.00
2 Fire guards	28.00
2 Ticket takers	30.00
6 Orchestra and sound effects	210.00
4 Singers	100.00
3 Porters	36.00
8 Ushers	80.00
Manager, per week	40.00
Assistant manager, per week	25.00
Stenographer and bookkeeper	15.00
Messenger boy	6.00
Telephone	2.00
Office supplies and sundry	6.00
Average weekly expenses	$2,145.00

Average weekly receipts, $4,450.

Country Theater (1). The theater from which this expense sheet was taken was unsuccessful. The expense seems about a minimum for a theater in which the manager must employ help for all of his service, yet the gross receipts of the theater did not justify even this expense.

WEEKLY EXPENSE SHEET

Rent	$ 3.50
Film service, 7 reels weekly	18.00
Express charges	1.00
Electricity	3.00
Operator	10.00
Ticket seller	1.50
Pianist	3.00
Coal (winter expense)	2.00
Tickets, carbons and sundry	1.00
Total weekly expense	$43.00

Average weekly receipts, $40.

This town had a census population of 1,100 people, giving a probable weekly ticket window income of $27.50 to $55.

Country Theater (2). In the same town, under a different manager. The experience of the first theater had shown about what gross income could be expected. The expense account was planned to fall below the anticipated income by enough to leave a profit for the manager.

WEEKLY EXPENSE SHEET

Rent	$ 3.50
Film, eight reels, express paid	12.00
Electricity	3.00
Operator	......
Ticket seller	1.00
Pianist	2.50
Coal (winter expense)	2.00
Tickets, carbons and sundry	1.00
Newspaper advertisements	.50
Total weekly expense	$25.50

Average weekly receipts, $45.

The commercial run of film satisfied his audience for quality, and age of subject was immaterial, as all were new to his patrons. The eight reels were run as follows: Two on Monday night, one new and one holdover on Tuesday night; one new and one holdover Wednesday night; one new and one holdover Thursday night; one new and one holdover Friday night; two new reels and one holdover Saturday afternoon and Saturday evening. This gave a three-reel show on Saturday and prices of ten cents for adults and five cents for children were charged.

The manager ran the projecting machine himself, thus avoiding an expenditure for an operator's salary.

The ticket seller sold tickets and noted that the patrons dropped them into a ticket box at the door, which box could be seen by the manager from time to time as he chanced to look.

The pianist seems the only luxury on the bill of expense. The small advertisement in the local newspaper seems good business judgment.

Country Theater (3). In the same town, during the summer.

During this season, the patronage of the country folk is largely withdrawn except on Saturdays. The operation of the picture theater was changed to suit the changed conditions for the summer months.

The theater building or room was held over the summer at the uniform rental rate for the following winter's business. The film service was reduced to three reels for the Saturday show, and shows were given only on Saturday afternoon and evening. Admission was five and ten cents, as on Saturdays during the winter.

WEEKLY EXPENSE SHEET

Rent	$ 3.50
Film, three reels express paid	5.00
Electricity	1.00
Ticket seller	.25
Pianist	.75
Sundry expense	.50
Newspaper advertisements	1.00
Total weekly expense	$12.00

Receipts averaged between $15 and $20 weekly. In addition to the profit of the one day at the theater, the manager had other employment during the week.

Country Theater (4). This theater is located in a country town whose census population is but six hundred people. The gross income which might be expected in such a town, according to the rule, would be $15 to $30 per week, and this is based upon a show running six nights and one afternoon per week.

WEEKLY EXPENSE SHEET

Rent, heat and ticket seller, two days	$ 3.00
Film, five reels, two days	4.50
Express charges	.35
Expense for acetylene-lamp supplies	.30
Sundry expenses	1.00
Total weekly expense	$ 9.15

Average weekly receipts, $14.

For an exhibition room, a lodge hall seating about one hundred and twenty-five people was obtained at a price of two nights for $3, including the heating, and a ticket seller was furnished as a favor.

The item of film, five reels for $4.50, was attained by "splitting the week" with another theater in a neighboring town, which used the five reels during the remainder of the week.

The total expense of starting this theater was about $60 for a complete projecting outfit with acetylene lamp. Aside from this there was no expense but the curtain for the picture screen. The manager and operator was regularly employed during the day, his show profits being "velvet."

The program given was three reels the first night and two new reels and a selected holdover reel for the second night. The price was five cents.

Airdome. This name has been adopted to define a motion-picture theater in the open air. A fenced enclosure is chosen, or a canvas 8 to 10 feet high is erected upon stakes to form an enclosed yard. At one end a projection house or even a projection platform is built; at the other end, a picture screen of usual theater size is erected. Chairs are arranged before the screen as in any motion-picture theater, and the entire conduct of the airdome is quite the same. A platform may be built before the screen for vaudeville.

The airdome is for fair weather only. The novel idea seems to please the general public, whether the airdome is operated in a country town or upon a vacant lot in a large city.

The illustration, Fig. 5, shows an airdome upon a city lot

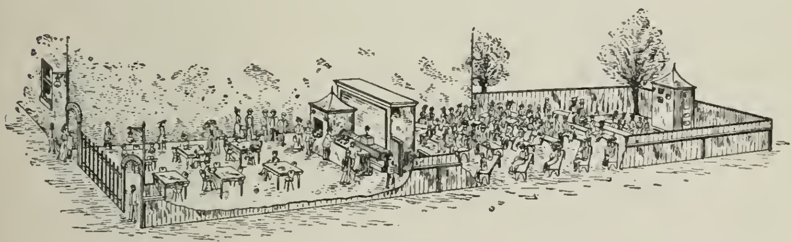


Fig. 5. The Airdome

beside a business house. The lot is divided by the picture screen and the admission gate, the front portion of the enclosure being used as a refreshment park in which the music from the airdome piano or orchestra (if any) is heard, while the rear portion of the lot is the theater itself.

OPERATION

Studying Audiences. The manager will learn much about his show by watching his patrons as they come out. It is not necessary to inquire what they think of the show Comments will pass among them which may be overheard by the manager and by the cashier as they pass the ticket window, commenting favorably and unfavorably upon the film pictures which they have seen a few minutes before. In this manner the manager may learn when any particular picture has favorable comment, and may endeavor to have his film exchange supply more of the same class; likewise, when any picture has a flood of unfavorable comment among the theatergoers themselves, the manager may try to influence his film exchange to avoid sending him that class of subject.

The words, "try to influence his film exchange," are chosen carefully to express the true position of the exhibitor, or theater manager, in the matter of obtaining film pictures acceptable to his patrons. The film exchanges as a rule take all the film pictures produced by the particular manufacturers from whom they buy. All of these film reels look alike to the film exchange man, and he would like to send them indiscriminately to his customers, to the exhibitors, or to theater managers. The service the theater manager will get, therefore, will be "hit or miss" of the film exchange stock of reels unless some influence is used by the manager to govern the classes of pictures furnished him. Film exchanges are notoriously lax in the matter of selecting pictures for particular theaters. If the film service is to be what the manager desires, the deliveries of the film exchange must be watched constantly and carefully.

The manager who has learned the tastes of his audience should consider their tastes as a requirement upon him to obtain the preferred classes of pictures from his film exchange. The responsiveness of the audience in the theater is one barometer of public approval; the attitude and conduct of patrons leaving the theater is another. The ticket sales will be another, but this last is not so quick in its indications of response.

When a picture pleases the audience, it may be the specific picture, or it may be the general class to which the picture belongs; in one neighborhood, dramatic and scenic may please more than comic or historical; in another nothing but comics can draw the crowds and send them away smiling.

The Program. Whether vaudeville is advisable and profitable, and whether the song is a drawing card or whether the audience would rather have solid pictures, all may be learned from watching the house during the performance and watching the faces and comments of the patrons as they pass out after seeing the performance.

Choice of a program is a great factor where the theater is in a competitive position. There is but little difference in expense between a three-reel program and two reels and a song.

Advertising. A sign at the door of the theater may announce the titles of the films being shown, or may announce merely that motion pictures are being shown. It is customary to announce the titles of the films if the films can be obtained from the film exchange

Fig. 6. A Title Poster

long enough in advance to prepare the sign, or if posters are delivered with the films. At times it may help business to advertise the name of the maker rather than the name of the film, or to post the announcement as to the nature of the picture, "A roaring farce tonight," or "Beautiful colored picture tonight," rather than a title which might not suggest the nature of the film. In all of these details of his announcement boards at the front of the theater, the manager must use his judgment as applied to his patrons. Variation in signs is advisable; and always bear in mind that the program, the film pictures, the song and the music, or vaudeville, if any, if mentioned in the theater-front signs, must justify the sign and fulfil all its promises.

Poster Service. Title posters may be obtained from the film exchanges at a very small cost—five cents each is the usual charge—or they may be obtained from companies making a specialty of supplying title posters for films. These come in one-sheet size—the standard title poster size adopted by all film makers—and have something the appearance of the poster of Fig. 6. The charge for a poster service consisting of a weekly shipment of posters for the current films, which the theater manager then holds until he gets the films and ultimately throws away the posters which he has received for which he never got the films, is from $5 to $10 per month.

In addition to simple "title posters" containing a stock form of border design (sometimes in color) and the title of the film printed upon it, the film manufacturers publish with each film an attractive colored poster, one-sheet size. A quantity of these are delivered to the film exchange with every film sold, and in turn the film exchange will furnish them to the exhibitor to whom the film is rented. As to the terms upon which the exhibitor may secure these posters, that is a matter individual to the film exchange. Usually they are furnished free to the customers who get the films first, paying the higher prices for the early runs of the film. Later users of the film do not get any posters because they are all gone. The "title poster" service is a resource when the manufacturer's more desirable picture posters cannot be obtained.

Electric Signs. An electric sign, with a word in letters formed by electric lamps, such as "Theater," "5c Theater," "Motion," or "Pictures," or even "5c," can be seen a long way up and down the street.

A simple electric sign is illustrated in Fig. 7. This has the words, "Theater 5c," in letters studded with electric lamps. With 4-candle-power lamps taking about 12 watts each, and with electric current at 10 cents per kilowatt, the cost of current for operating this sign four hours in an evening would be about fifty cents. To this may be added cost of lamp renewals, interest, and depreciation on the sign, if so desired. The cost of such a sign is about $50.

Another type of electric sign is shown in Fig. 8, in which the letters are not studded with lamps, but in which the lamps of the sign form the attractive feature. The figure *5c* in the middle of the sign is set with lamps, and the zigzag line from the upper right-hand corner to the lower left-hand corner is set with a line of lamps. A *sign flasher* is connected with this sign, lighting the lamps in this order: The zigzag line represents a lightning flash. The first lamp at the top is lighted, then the next, and so on until about eight are lighted, then as each lamp ahead is lighted the lamp earliest lighted of the eight is put out, so that the string of eight lamps seems to move along the zigzag line. This action is very rapid, and the lightning flash crosses the sign very quickly. Then the *5c* is lighted for a few seconds, then extinguished for a few seconds, and the lightning flash is repeated, beginning the next cycle. The flashing of the lamps is done by a drum of contacts run by a small motor. The number of lamps is about the same as in the sign of Fig. 7, and the cost of current is about the same, the lamps burning but a part of the time, and the motor running all the time. The first cost of the sign is much greater.

Fig. 7. A Simple Electric Sign

Fig. 8. Electric Sign with Flasher

In a simple sign bordered by lamps, the lamps may be made to "run around" in the same way that the flash crosses the sign of Fig. 8, adding to the attractiveness of an otherwise very plain sign.

Announcement Slides. The program of the theater always may be announced by advertising announcement slides. These take the form of "Pictures Changed Daily," "Song Changed Twice a Week," "New Song Tomorrow," "Colored Picture Tomorrow Night," "Special Educational Show for School Children, one hour, beginning at four o'clock Friday," all of which are direct advertising slides, but will not be so considered by the patrons because they pertain to the show. Although they take but a minute or two, they may well be omitted on Saturday night's rush, particularly if so doing will put on one more show in the evening.

"Next show" slides are of doubtful utility, announcing the subjects for tomorrow. It is doubtful whether at any time it is advisable to announce the subjects for tomorrow, if competitive theaters are near by, unless the subject is a special one and, therefore, specially advertised. When used, the "next show" slides must be prepared by the theater manager or projection operator, from day to day, as the titles are learned ahead.

Printed Programs. With "daylight pictures"—the expression is used to mean that the lights of the room are not turned off while the pictures are being shown—a printed program may be given to the patron at the door. The printed program always carries advertising matter, and should be so designed as to advertise the theater properly, as well as to serve its paid advertisers.

Newspapers. Advertisements inserted in the newspapers are seldom profitable in the large cities; in the smaller cities, it may be found so; but in the country town, where the newspaper is a weekly and everybody reads all of it, 50c or $1 per week is well spent. The simple announcement, with some display line in it, may or may not give the titles.

Handbills. In the large city, the theater located in the residence district will find that the handbill will take the place of the newspaper in the small town, and cost but little more. A thousand bills, 6 by 9 inches in size, may be had from the local printer for a price not to exceed $2, and a boy, at $1 for the afternoon, will deliver them. This expense should put a handbill into every residence within five blocks of the theater. Such a handbill should contain some special announcement as an excuse for its existence; the title and short mention of the nature of some special film to be featured will be sufficient excuse; or a prize voting contest, or special program of specific nature.

Noise Wagon. Painted banners are mounted on a wagon—sometimes called a "sandwich wagon"—and driven through the streets, a bell being hung inside which rings continually, or a drummer or bugler being carried. Its utility is limited. Days when the country people are in town form one excuse for this advertising device.

Feature Films. The manager should see the film himself before deciding to feature it. It may be seen at some other theater or at the film exchange; the film exchange will be able to tell the manager where the film is being shown, that he may go there to see it. The fact that a specific film is being advertised largely by its manufacturer is not sufficient basis for a manager to decide to feature it for his patrons, for such advertising may not be justified by the film, or even if so warranted, the film may have real merit and still not be suited to the tastes of the theater as the manager understands them.

Having selected a feature film, advertise it only a day ahead, both by theater-front signs and handbills. In addition, a printed program for the next night with the feature film advertised may be handed to patrons leaving the theater on the night before the feature is put on. Be careful that the word "Tomorrow" is prominent in the theater-front announcement which is posted a day ahead, or some patron, reading the sign carelessly, may go inside and be disappointed because he did not see the feature film mentioned for the next night.

Special Programs. An entire program made up of films of some specific nature may be called a special program, and advertised accordingly. "Biograph Night" on which nothing but biograph reels are used, might strike the popular fancy of some neighborhood, while "Travel Night" on which the majority of films are scenic, might "make a hit" with another neighborhood.

School Children. A special program of films particularly pleasing to children, and to some extent educational or travel, may be given in the afternoon after the close of school, and the result of the experiment noted. Special arrangements with the film exchange will be necessary, and a talk will be needed with the educational or travel films, otherwise they are usually too unfamiliar to the child mind and, therefore, dry and uninteresting.

Amateur Night. As a part of one show of the evening, amateurs are invited to entertain the audience, with a time limit of five minutes each; after all have done their acts, each walks upon the stage; each patron in the audience has been requested to decide upon the prize-winning act, and when the selected amateur enters the patrons favoring him applaud. The amateur getting the greatest applause is awarded the advertised prize of the evening. "Amateur Night" is usually made a weekly event in theaters where it is introduced.

Contests. This is merely a specialized "amateur night" in which all acts are limited to the same nature, thereby placing the several acts in direct contest with each other.

Double Price. A five-cent theater may run on Saturday night at a ten-cent admission fee. This not only increases the gross receipts for Saturday evening but acts as an advertising feature for the theater. A better show should be given, to justify the double price, in order that the patrons may not think the double price is being charged merely because the manager can get it on Saturday. The program, however, should not require double time, or there will be no gain by the double price. It may be slightly longer in time, and may have advertisable differences in quality if desired.

The live manager will find some excuse to make a special noise once in a while to get a few new patrons to come to his theater because of the special feature advertised.

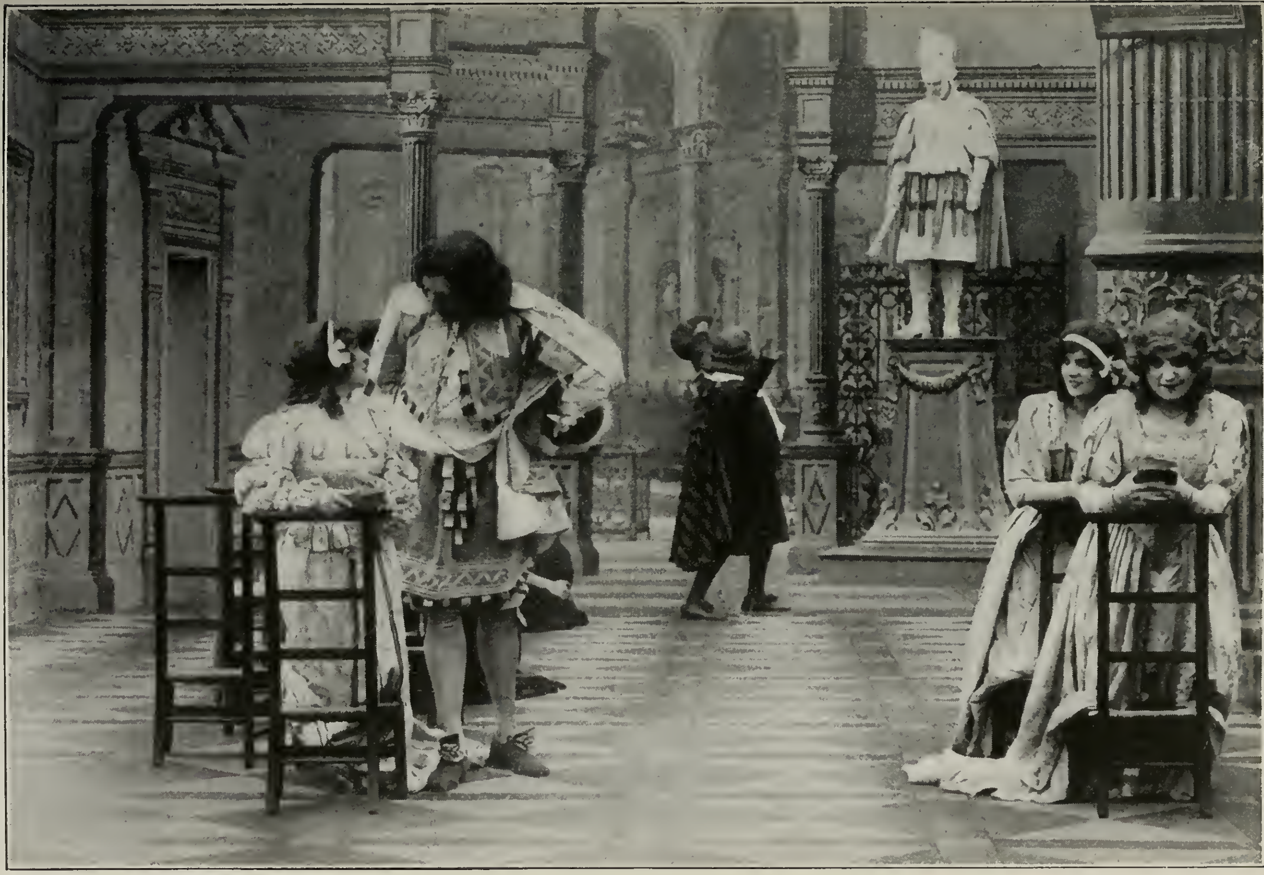
Renting Films. Subscribe for a magazine devoted to motion-picture interests, and read the advertisements of the film exchanges. Select two or three liberal advertisers near the theater and get their prices. Films contracted for as "not more than thirty days old" will be about the cheapest, quality considered. In the city, two reels, daily change, should cost $20 to $25 weekly. This is much better than "one reel ten days and one reel commercial," for "commercial" means "junk" to the exchange man. If you have film with a time limit, keep the file of the motion-picture magazine with its list of releases or clip and file the lists of releases and look up every film received to make sure that the exchange man is not giving you film older than your contract age. In a small town, the price to be paid for film will be limited by the gross income, and the manager must shop around the film exchanges to get the best he can for his money.

Get the benefit of competition among film exchanges by learning what others would charge for the service you are buying, but never change film exchanges without giving your own exchange a chance to meet the other fellow's prices and terms.

Song Slides. The slides are rented from the film exchange, although there are some exchanges handling song slides only. The price is 25 cents to $1 for the set of slides for a week or less, and extra for the sheet music if not returned with the slides.

Hiring Employes. In the cities, singer and pianist may be obtained in the neighborhood, by advertising in the daily papers or on the special program handbills. Either one should be em-

SCENE FROM PHOTOPLAY, "THE ROSE OF OLD ST. AUGUSTINE," OR "A TALE OF JEAN LAFITTE, THE PRIVATEER"
Courtesy of *Selig Polyscope Co., Inc., Chicago*



THE STATUE OF THE COMMANDER ACCEPTS DON JUAN'S INVITATION TO DINE
Scene from Photoplay, "Don Juan's Death"
Courtesy of *Eclair Film Co., Paris*

ployed at $1 to $1.50 per night. A drummer who is employed elsewhere during the day should have the same price. Cashier at $4 to $7 weekly is ample in the city. In the small towns, these prices may be cut one-half. The projection operator, with a license and a union in the city, must have $15 for evenings only. In the smaller towns, unless employed for the full day, he may be scheduled for one-half that price; this assumes that he is employed during the day elsewhere.

Automatic Music. An automatic piano may be rented or bought —$800 usually will buy one—and the perforated strip music may be obtained from a music exchange or "library" with daily or weekly charge at a price of $1 to $2.50 per month. The automatic piano may furnish the only music for an "all picture" show, or may be used early and late in the evenings to make the pianist's hours shorter and reduce the expense, besides being ready always to furnish music for a full evening when the pianist fails to appear.

Vaudeville. The acts must be booked from a dramatic booking agency; no other method is reliable nor satisfactory. A single act by a single actor may be put on at $25 per week and up. Any act will cost $25 per actor, and up from that price. If you are running vaudeville, by all means keep posted on what other theaters are doing, and get acquainted with their booking agencies, for competition's sake, to see that you are getting the best your money will buy.

Splitting the Week. Vaudeville is "weekly change." In the city, where the patronage of a residence district theater is limited to a small area, and in smaller cities, where a large proportion of patrons are likely to visit the theater oftener than one night in the week, the plan of "splitting the week" between two theaters is adopted to give each a change of vaudeville in the middle of the week. When two theaters are co-operating thus, films as well as vaudeville acts may be "split," particularly if the theaters are in two nearby country towns. Each theater hires a vaudeville act and a few reels of film for the week, and the entire program changes theaters in the middle of the week. Booking agencies will arrange for "split weeks" as desired.

Keeping Accounts. For theaters whose expenses and incomes run into hundreds of dollars weekly, a full double-entry set of books should be kept. For the smaller theaters, two books will answer the purpose very well. All theater accounts should be strictly cash. Since the ticket window account is strictly cash, there can be no good business policy in not having the expense account run on the same basis; if the cash from the income account will not pay cash for the expense account, quit the business or think of a good reason why not.

For a small theater, a little leather-covered pocket memorandum book may be used to write down all amounts paid out and received, for any purpose whatsoever. Memoranda of contracts and agreements may be entered in this book. The other book is a book of ruled pages, one for each week of the theater's operation; perhaps a book of fifty-two pages would be a convenient size, covering just a year of operation. The ruling of the pages of this book may be

	MO.	DAY	TITLE of FILMS	TITLE of SONGS	RECEIPTS		EXPENSES		
SUN.							RENT		
							ELECTRICITY		
MON.							FILM RENT		
							PIANO RENT		
TUES.							SLIDES		
							ADVERTISING		
WED.							EXPRESS		
							SALARY-OPERATOR		
THUR.							" SINGER		
							" PIANST		
FRI.							" TICKET SELLER		
							" DOOR KEEPER		
SAT.							" USHER		
							EXTRAS		
REMARKS:				ADMISSION RECEIPTS			TOTAL RECEIPTS		
				OTHER RECEIPTS			TOTAL EXPENSES		
				TOTAL RECEIPTS			NET PROFITS		

Fig. 9. Blank Form for Weekly Account of a Motion-Picture Theater

as shown in Fig. 9, or any modification of that form which suits the manager's fancy. A local printer would print a thousand of these on a good quality of letter paper for $4, and he would want about the same money for fifty-two of them, the principal labor being in the preparation of the printing form. By having them printed, the manager may have his own preferred ruling. Books answering the purpose may be bought for a year's business for a dollar or less.

Each day the titles of the films may be entered on the page. This is to prevent running the same film twice without a proper interval between, as might result from an error of the film exchange, or from a change in film exchanges. The songs are recorded likewise. Films and songs which seemed to be "hits" with the audience may be marked with a cross and asked for from the exchange as specials, "repeated by request" for advertising effect.

The ticket-window receipts and other receipts should be entered in the pocket memorandum book, and may be noted on the back of the weekly sheet until the end of the week, when the totals may be entered on the face of the weekly sheet, and the net profits for the week may be determined.

An extra sheet at the back of the book may have entered upon it in each space the total of the same space on all the weekly sheets. The net profits for the year thus may be shown, as well as a classification of the expenses for the year.

Dull Season. In summer-time in the country, the farmers are too busy to come to town except on Saturday afternoon. In summer-time in the city the people go to the parks or sit on their front porches. "In the good old summer-time," what is the picture-theater manager to do? If he worked hard during the winter, and expects to do the same next winter, it may be to his advantage ultimately to shut up the place for July and August, pay the rent on the vacant house, and take a thorough rest. A little painting and polishing may be done during this interval, and he can open the house with a big whoop and hurrah about September 1.

Another method is to make the show straight pictures, and cut the expense sheet to the absolute minimum; perhaps the ticket window will be able to get enough small coin to pay the operating charges. Nothing but a shopper's theater in the shopping center of a large city can run a summer show at winter profits. This excepts the picture show which is a part of a summer amusement park, and also the airdome. They are shows which flourish in the summer-time only.

A study of the weekly account sheets as summer approaches will show the dwindling profits. The manager then must decide what his policy for the summer will be.

Tickets and Chopper. Tickets will be furnished by the film exchanges at 15 to 20 cents per thousand, in rolls. They are sold by the cashier, and the proper amount of money which the cashier is to turn over to the manager may be determined by noting the number of the end ticket of the roll before the show and subtracting it from the end ticket of the roll after the show, multiplying the difference by the price of admission. This number of tickets should be found in the "ticket chopper," or ticket box, and also the numbers of the tickets in the box should correspond, if they were examined.

The ticket chopper takes its name from its function. It mutilates the ticket which is dropped into it in such manner that it may not be used again. Some choppers slit them into ribbons, while others punch holes in them, passing the tickets into one box and the small bits from the holes into another receptacle. In either case, the ticket if reclaimed from the box by fraud would not be suitable for use again. Where a ticket box which does not chop is used, the manager should give his personal attention to destroying the tickets each day, preferably by burning them. Every ticket that is not destroyed by the manager himself means a possible loss of five cents, for it might be used at the door again, even though its destruction is intrusted to another.

Change the color every day, having several rolls of different color, and using sometimes one and sometimes another. A ticket of the wrong color dropped into the ticket box will reveal an irregularity which may lead to important discoveries in the accounting system.

A quiet and accurate "head count" of people entering the theater door on an occasional night, compared with ticket numbers and cashier's receipts, will help to keep this most vital detail of the theater under control.

The manager sometimes is confronted with a class of patrons who stay in the theater longer than one show, and, therefore, longer than one admission fee justifies. When the house is "holding out" the crowds, each patron of this class reduces the profits of the theater. One method of handling this problem is to take tickets at the door until the first show begins; after that, do not take up the whole ticket, but tear off about one-quarter, permitting the patron to retain the large part of the ticket. This gives each patron entering during the show a torn ticket. Between shows, collect tickets from all in the theater. Those having no torn tickets must have seen the entire performance, and should pay another admission fee or leave the theater.

Side Lines for Profit. The patron has a sentiment against any form of advertising *in the theater.* For the theater in a competitive position, it is a good plan to avoid all semblance of advertising inside the theater—upon the walls or upon the picture screen, either drop curtain or lantern slides. The tone of the theater is improved by leaving the show clean and free from advertising of any kind, particularly if the competing theaters offer objectionable advertising matter. At the same time, the big vaudeville houses of the cities use their advertising drop curtain before the performance and put advertising matter in their street scenes. Also, the legitimate theaters sell candy in the auditorium between the acts and before the performance begins. The manager must judge his people on these points and handle his advertising accordingly.

Following are a few plans available for increasing the revenue of a theater beyond ticket-window receipts:

Wall Posters. This plan is borrowed from the street-car practice of assigning a wall space for advertising matter. The street-car practice is not objectionable, because the space is well chosen and advertising matter is confined strictly to the selected space. As to its application in any specific theater, the sentiment of the patrons must be judged. Many things will pass in a small country town which would not be endured by patrons in a city.

Advertising Drop Curtain. The picture screen is an unsightly object in the theater when there is no projected picture upon it. The appearance of the room is improved greatly during the intermission by lowering an ornamental drop curtain over the picture screen. This drop curtain may contain advertising matter. It should be well put on—at the expense of the advertising client—and a liberal price charged.

Advertising Slides. Advertising slides bear advertising matter for the advertising patron, and such slides are thrown upon the screen along with the set of announcement slides with which the program begins, before the motion pictures start. A single advertising slide is hardly objectionable anywhere, but too many will ruin the show.

In connection with advertising slides, insist that the slides be pleasing in appearance and brief in words. Of course the cost of making the slide is paid by the advertiser. Remember that the same people come to your theater every week, and insist upon a weekly change of the advertising slide also. The patron who comes the second time comes to see a different show. Not only the advertising slides of the paid advertiser must be changed often, but the announcement slides which are in substance advertising slides of the theater itself, must be changed. Old slides which have been on the shelf a few weeks may be "run" again as new from time to time, but change the slide program for the same reason that you change the picture program and the song program. Your people want something new all the time.

Don't let any patron get the thought that the manager is asleep or that the theater is not keeping up with every other theater in the land.

Program Advertising. This is a practice set by the large theaters. No theater program is complete without advertising matter upon it, and this can be obtained from local merchants at prices which will assist in paying the expense of printing the theater's program, or even yield a profit.

In soliciting program advertising, remember that the advertisement will increase the size and cost of the program, so that the price must be still greater than the difference in cost which the printer will make. The difference in cost may be learned by getting prices from the printer for the programs with and without advertising.

Handbills. The weekly handbill is worth its cost in any city show. The cost may be reduced by carrying the advertisement of a local merchant, or two or three in different lines of business, for a price in excess of the added cost of the bills at the printer's. In addition, a proportion of the distributing charge is added to the price for the merchant, always keeping the price to him lower than what it would cost him to print and distribute bills of his own.

Candy Kid. The practice of selling candy in theaters before and between acts is well established. Remember in this connection that the patrons come to the theater to be amused. The candy vendor can help much in their entertainment if his "act" is studied. One successful candy vendor waits only until the old crowd is out and then as soon as the new patrons start in he walks before the picture screen and says something like this: "I know, ladies and gentlemen, that you have come here tonight for a little fun, sport and amusement, and I am going to add to your fun just as much as I possibly can; I have tonight a package of —— candy which I am selling for five cents; as I pass up the aisle please have your change ready." He passes up the aisle with his basket as soon as the aisle is clear, selling candy and making remarks to entertain the crowd: "Don't be afraid to buy it; it's worth the money;" "The young man takes two packages because the young lady knows it's good;" "Every package guaranteed to send you home fat and happy;" "After you eat it, if you don't like it, give it back and I'll refund the nickel;" when the show starts before he has finished his trip, he says, "Keep your eyes on the pictures and hand me your money." Your people have come to your theater to be entertained; your candy vendor is making the intermission seem shorter and is positively adding to their entertainment.

Avoid the error of giving the candy vendor too much time. An intermission of eleven minutes has been observed and reported, "to allow the candy man to distribute his free samples, make a second tour of the audience to sell his confectionery, then a third tour to sell some songs." Not only will the audience resent the delay to the pictures, but the theater may actually lose money. When the house is running crowded, and patrons are waiting at the door, the number of tickets sold depends upon the speed with which those inside may be shown the entire program, that they may leave and make room for others. A 300-seat house, at 5-cent admission, running a 45-minute program, under crowded conditions, is making $15 for each program, or about 33 cents per minute while the pictures are on the screen. Assuming that the candy vendor will be able to sell fifty packages of candy at five cents each—a phenomenal sale for so small a house—and at a profit of two cents each to the theater, then for that $1 profit on the candy he is entitled to just three minutes' intermission.

To extend the intermission one minute is to lose more money at the ticket window than is made at the candy basket. When the theater manager understands this clearly, he will be in possession of a fundamental principle which applies to all other side lines for profit: *Only when the side line does not decrease the ticket window receipts, only when it leaves them unchanged or actually increases them, may it be considered as desirable or profitable.*

Slot Machines. The lobby, or entrance of the theater in front of the partition, offers space for a few compact automatic vending machines, if, in the manager's best judgment, such a plan is advisable. If the police regulations of the town will permit, an automatic vending machine may stand on the sidewalk at each side of the theater, just in the foot square of sidewalk space at the end of the theater's side walls.

Sheet Music Sales. It is a favor to many patrons to advise them where sheet music of the song may be obtained. An announcement slide, "The song on our program is always for sale at our ticket window," has no objection and does not seem advertising matter because it pertains to the theater.

Refreshment Annex. In the airdome, the refreshment business is so much associated with the motion-picture business, and they are so mutually helpful to each other that they usually are run in conjunction, each to boost the other. In the motion-picture winter theater, the relation cannot be so boldly emphasized or the departure from custom will be noted and adversely commented upon, but a candy store and soda fountain located near a motion-picture theater will do a larger business than if the theater were not there.

SCENE FROM "A PRIESTESS OF CARTHAGE," BY GAUMONT
Note the Careful Attention to Detail in Costumes, Architecture, and Foliage
Courtesy of the *Kleine Optical Co., Chicago*

SCENE FROM PHOTOPLAY, "THE LAST APPEAL"
Courtesy of *Independent Moving Pictures Co., New York*

ELECTRICAL PRINCIPLES

In the management of a motion-picture machine and theater the operator, even if he be well versed in the practical methods of running circuits for his machine, finds that he needs a knowledge of the elementary principles of electricity and some clear conception of how the electric current behaves in various types of circuits. It must be borne in mind, therefore, that only material deemed pertinent to the case has been included in this book. Those desiring more information are referred to any standard text.

ELECTRICITY IN MOTION—ELECTRICAL CURRENTS

Magnetic Effect Due to a Charge in Motion. An electrical charge at rest produces no magnetic effect whatever. This can be proved by bringing a charged body near a compass needle or suspended magnet. It will attract both ends equally well by virtue of the principle of electrostatic induction. If the effect were magnetic, one end should be repelled and the other attracted. Again, if a sheet of zinc, aluminum, or copper is inserted between the deflected needle and the charge, all effect which was produced upon the needle by the charge will be cut off, for the metallic sheet will act as an electric screen. But if such a metal screen is inserted between a compass needle and a magnet, its insertion has no effect at all on the magnetic forces.

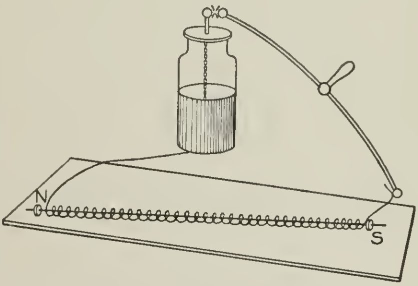


Fig. 1. Magnetic Effect of Electric Current

If, however, a charged Leyden jar is discharged through a coil which surrounds an unmagnetized knitting needle in the manner shown in Fig. 1, the needle will be found, after the discharge, to have become distinctly magnetized.

This experiment demonstrates the existence of some connection between electricity and magnetism. Just what this connection is, is not yet known with certainty; but it is known that *magnetic effects are always observable near the path of a moving electrical charge,* while no such effects can ever be observed near a charge at rest.

An electrical charge in motion is called an electrical current, and the presence of such current in a conductor is most commonly detected by the magnetic effect which it produces.

Galvanic Cell. When a Leyden jar is discharged, but a very small quantity of electricity passes through the connecting wires, since the current lasts but a small fraction of a second. If we could keep the current flowing continuously through the wire, we should expect the magnetic effect to be more pronounced. This might be done by discharging Leyden jars in rapid succession through the wire. In 1786, however, Galvani, an Italian anatomist at the University of Bologna, accidently discovered that there is a chemical method for producing such a continuous current. His discovery was not understood, however, until Volta, professor of physics at Como, devised an arrangement which is now known sometimes as the *voltaic,* sometimes as the *galvanic* cell.

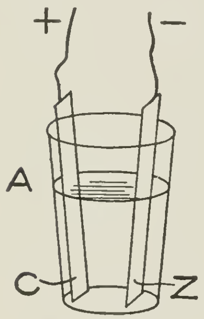


Fig. 2. Simple Galvanic Cells

Such a cell consists in its simplest form of a strip of copper and a strip of zinc immersed in dilute sulphuric acid, Fig. 2. If the wires leading from the copper and the zinc are connected for a few seconds to the end of the coil of Fig. 1, when an unmagnetized needle lies within this coil, the needle will be found to be much more strongly magnetized than it was when the Leyden jar was discharged through the coil. Or, if the wire connecting the copper and zinc is simply held above the needle in the manner shown in Fig. 3, the latter will be found to be strongly deflected. It is evident from these experiments that the wire which connects the terminals of a galvanic cell carries a current of electricity. Historically, the second of these experiments, performed by the Danish physicist Oersted in 1819, preceded the discovery of the magnetizing effect of currents upon needles. It created a great deal of excitement at the time because it was the first clew which had been found to a relationship between electricity and magnetism.

It might be inferred from the above experiments that the two plates of a galvanic cell when not connected by a wire carry static

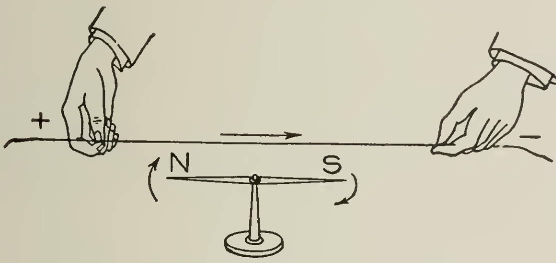


Fig. 3. Magnetic Effects of Current

positive and negative charges just as do the two coats of a Leyden jar before it is discharged through the wire. This inference can be easily verified with an electroscope.

Thus, if a metal plate *A*, Fig. 4, covered with shellac on its lower side and provided with an insulating handle, is placed upon a similar plate *B* which is in contact with the knob on an electroscope; and if the copper plate, for example, of a galvanic cell is connected to *A* and the zinc to *B;* then, when the connecting wires are removed and the plate *A* lifted away from *B*, the leaves of the electroscope will diverge and when tested will be found to be negatively charged. If the deflection observed in the leaves of the electroscope is too small for the purposes of demonstration, the conditions can be bettered by using a battery of from five to ten cells instead of the single cell. If, however, the plates *A* and *B* are sufficiently large—say, 3 or 4 inches in diameter—and if their surfaces are very flat, a single cell will be found to be sufficient. If, on the other hand, the copper plate is connected to *B* and the zinc to *A* in the above experiment, the elec-

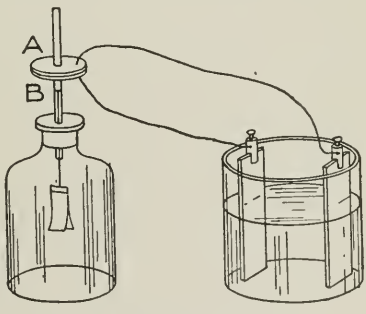


Fig. 4. Static Charges on Plates of Galvanic Cell

troscope will be found to be positively charged. This shows clearly that the copper plate possesses a positive electrical charge, while the zinc plate possesses a negative charge, these charges originating in the chemical action within the galvanic cell.

In this experiment the two metal plates separated by shellac constitute an electrical condenser which is charged positively on one side and negatively on the other by connecting it with the two plates of the galvanic cell, in precisely the same way in which a Leyden jar is charged by connecting its two coats one to one terminal and the other to the other terminal of a static machine. The potential of the plate *B* is increased by moving *A* away from it. This device makes it possible to detect very small potential differences.

Comparison of a Galvanic Cell and Static Machine. If one of the terminals of a galvanic cell is touched directly to the knob of the gold-leaf electroscope without the use of the condenser plates *A* and *B* of Fig. 4, no divergence of the leaves can be detected; but if one knob of a static machine in operation were so touched, the leaves would be thrown apart very violently. Since we have seen that the divergence of the leaves is a measure of the potential of the body to which they are connected, we learn from this experiment that the chemical actions going on in a galvanic cell are able to produce between its terminals but very small potential differences in comparison with that produced by the static machine between its terminals. As a matter of fact, the potential difference between the terminals of the cell is but one volt, while that between the terminals of an electrical machine may be several hundred thousand volts.

On the other hand, if the knobs of the static machine are connected to the ends of the wire shown in Fig. 3, and the machine operated, the current will not be large enough to produce any appreciable effect upon the needle. Since, under these same circumstances the galvanic cell produced a very large effect upon the needle, we learn that although the cell develops a much smaller p. d. than does the static machine, it nevertheless sends through the wire a very much larger amount of electricity per second. This means merely that the chemical actions which are going on within the cell are able to recharge the plates when they become discharged through the electric wire, far more rapidly than is the static machine able to recharge its terminals after they have once been discharged.

Shape of Magnetic Field about a Current. If we place the wire which connects the plates of a galvanic cell in a vertical position, Fig. 5, and explore with a compass needle the shape of the magnetic field about the current, we find that the magnetic lines are concentric circles lying in a plane perpendicular to the wire and having the wire as their common center. If we reverse the direction of the current, we find that the direction in which the compass needle points reverses also. If the current is very strong, say 40 amperes, this shape of the field can be shown by scattering iron filings on a plate through which the current passes, in the manner shown in Fig. 5. The relation between the direction in which the current flows and the direction in which the positive end of the needle points—this is by definition, the direction of the magnetic field—is given in the following rule: *If the right hand grasps the wire as in Fig. 6, so that the thumb points in the direction in which the positive electricity is moving, that is, in the direction from the copper toward the zinc, then the magnetic lines encircle the wire in the same direction as do the fingers of the hand.* Another way of stating this rule is as follows: *The relation between the direction of the current in a wire and the direction of the magnetic lines about it, is the same as the relation between the direction of the forward motion of a right-handed screw and the direction of rotation when it is being driven in.* In this form the rule is known as the *right-hand screw rule.*

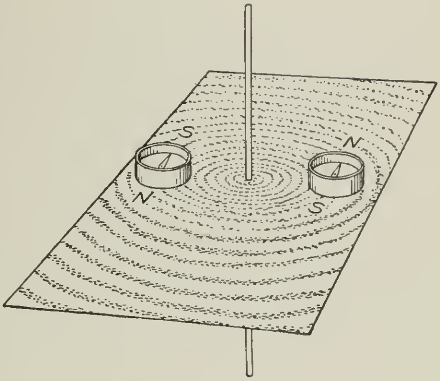


Fig. 5. Magnetic Field Around a Conductor

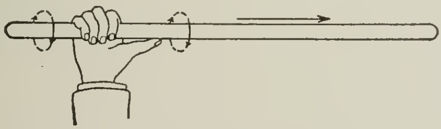


Fig. 6. Right-Hand Screw Rule for Direction of Magnetic Field

Measurement of Electrical Currents. Electrical currents are, in general, measured by the strength of the magnetic effect which they are able to produce under specific conditions. Thus, if the wire carrying a current is wound into circular form as in Fig. 7, the right-hand screw rule shows us that the shape of the magnetic field at the center of the coil is similar to that shown in the figure. If, then, the coil is placed in a north-and-south plane and a compass needle is placed at the center, the passage of the current through the coil tends to deflect the needle so as to make it point east and west. The amount of deflection under these conditions is taken as the measure of current strength. The unit of current is called the *ampere* and is, in fact, approximately the same as the current which, flowing through a circular coil of three turns and 10 centimeters radius, set in a north-and-south plane, will produce at Washington

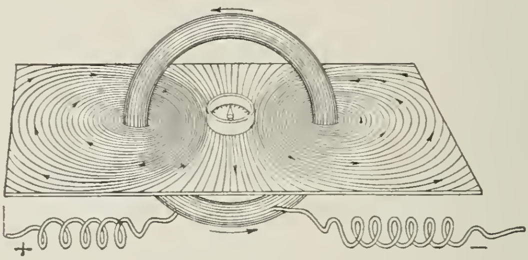


Fig. 7. Plotting Field About Circular Conductor

a deflection of 45 degrees in a small compass needle placed in its center, as in Fig. 7. Nearly all current-measuring instruments, commonly called *ammeters,* consist essentially either of a small magnet suspended at the center of a fixed coil as in Fig. 7, or of a movable coil suspended between the poles of a fixed magnet. The passage of the current through the coil produces a deflection, in the first case, of the magnetic needle with reference to the fixed coil, and in the second case, of the coil with reference to the fixed magnet. If the instrument has been suitably calibrated, the amount of the deflection gives at once the strength of the current in amperes.

Electromotive Force and Its Measurements. The potential difference which a galvanic cell or other generator of electricity is able to maintain between its terminals when these terminals are not connected by a wire, *i. e.,* the total electrical pressure which the

MARION RECEIVES THE NOTE

Scene from Pathé film, "Mistaken Identity"
Courtesy of *Pathé Frères, New York and Paris*

SCENE FROM PHOTOPLAY, "THE NIECE AND THE CHORUS LADY"
Courtesy of *Thomas A. Edison, Inc., Orange, N. J*

generator is capable of exerting, is commonly called its *electromotive force*, or *e. m. f.* *The e. m. f of an electrical generator may then be defined as its capacity for producing electrical pressure, or p. d.* This p. d. might be measured by the deflection produced in an electroscope, or other similar instrument, when one terminal was connected to the case of the electroscope and the other terminal to the knob. Potential differences are in fact measured in this way in all so-called electrostatic voltmeters, which are now coming more and more into use.

The more common type of potential difference measurers, so-called *voltmeters*, consists, however, of an instrument made like an ammeter, save that the coil of wire is made of an enormous number of turns of extremely fine wire, so that it carries at very small current. The amount of current which it does carry, however, and therefore the amount of deflection of its needle, is taken as proportional to the difference in electrical pressure existing between its ends when these are touched to the two points whose p. d. is sought. The principle underlying this type of voltmeter will be better understood from a consideration of the following water analogy. If the stopcock *K* Fig. 8, in the pipe connecting the water tanks *C* and *D* is closed, and if the water wheel *A* is set in motion by applying a weight *W*, the wheel will turn until it creates such a difference in the water levels between *C* and *D* that the back pressure against the left face of the wheel stops it and brings the weight *W* to rest. In precisely the same way, the chemical action within the galvanic cell whose terminals are not joined, Fig. 9, develops positive and negative charges upon these terminals, that is, creates a p. d. between them, until the back electrical pressure through the cell due to this p. d. is sufficient to put a stop to further chemical action.

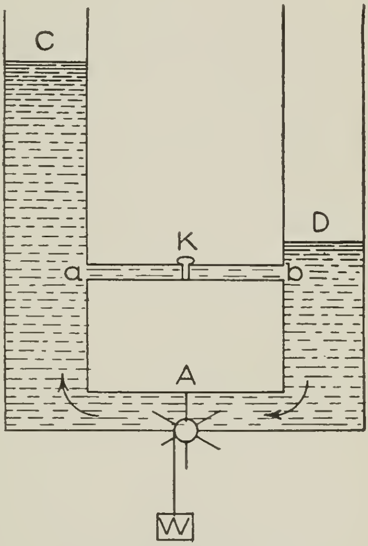


Fig. 8. Hydrostatic Analogy of Potential Difference

Now, if the water reservoirs, Fig. 8, are put in communication by opening the stop-cock K, the difference in level between C and D will begin to fall, and the wheel will begin to build it up again. But if the carrying capacity of the pipe $a\ b$ is small in comparison with the capacity of the wheel to remove water from D and to supply it to C, then the difference of level which permanently exists between C and D when K is open will not be appreciably smaller than when it is closed. In this case the current which flows through AB may obviously be taken as a measure of the difference in pressure which the pump is able to maintain between C and D when K is closed.

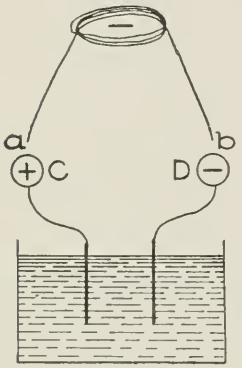


Fig. 9. Principle of Common Voltmeter

In precisely the same way, if the terminal C and D of the cell, Fig. 9, are connected by attaching to them the terminals a and b of any conductor, they at once begin to discharge through this conductor, and their p. d., therefore, begins to fall. But if the chemical action in the cell is able to recharge C and D very rapidly in comparison with the ability of the wire to discharge them, then the p. d. between C and D will not be appreciably lowered by the presence of the connecting conductor. In this case the current which flows through the conducting coil, and, therefore, the deflection of the needle at its center, may be taken as a measure of the electrical pressure developed by the cell, that is, of the p. d. between its unconnected terminals.

The common voltmeter is, then, exactly like an ammeter, save that its coil offers so high a resistance to the passage of electricity through it that it does not assist appreciably in discharging, that is, in reducing the p. d. between the points to which it is connected.

The unit of p. d. may be taken for practical purposes as the electrical pressure produced by a simple galvanic cell consisting of zinc and copper immersed in dilute sulphuric acid. It is named a *volt* in honor of Volta.

Electromotive Forces of Galvanic Cells. When a voltmeter of any sort is connected to the terminals of a galvanic cell, it is found that the deflection produced is altogether independent of the shape or size of the plates or their distance apart. But if the nature of the plates is changed, the deflection changes. Thus, while copper and zinc in dilute sulphuric acid have an e. m. f. of one volt, carbon and zinc show an e. m. f. of at least 1.5 volts, while carbon and copper will show an e. m. f. of very much less than a volt. Similarly, by changing the nature of the liquid in which the plates are immersed, we can produce changes in the deflection of the voltmeter. We learn, therefore, that *the e. m. f. of a galvanic cell depends simply upon the materials of which the cell is composed and not at all upon the shape, size, or distance apart of the plates.*

Electrical Resistance. If the terminals of a galvanic cell are connected first to, say, 10 feet of No. 30 copper wire, and then to 10 feet of No. 30 German-silver wire, it is found that a compass needle placed at a given distance from the copper wire will show a much larger deflection than when placed the same distance from the German-silver wire. A cell therefore, which is capable of developing a certain fixed electrical pressure is able to force very much more current through a given wire of copper than through an exactly similar wire of German-silver. We say, therefore, that German-silver offers a higher *resistance* to the passage of electricity than does copper. Similarly, every particular substance has its own characteristic power of transmitting electrical currents. Silver being the best conductor of any known substances, the resistances of different substances are commonly referred to silver as a standard, and the ratio between the resistance of a given wire of any substance and the resistance of an exactly similar silver wire is called the *specific resistance* of that substance. The specific resistance of some of the commoner metals are as follows:

Silver	1.00	Soft iron	7.40	German silver	20.4
Copper	1.13	Nickel	7.87	Hard steel	21.0
Aluminum	2.00	Platinum	9.00	Mercury	62.7

The unit of resistance is the resistance of 0° of a column of mercury 106.3 centimeters long and 1 square millimeter in cross-section. It is called an *ohm,* in honor of the great German physicist, Georg Ohm (1789-1854). A length of 9.35 feet of No. 30 copper wire, or 6.2 inches of No. 30 German-silver wire, has a resistance of about one ohm. Copper wire of the size shown in Fig. 10 has a resistance of about 2.62 ohms per mile.

The resistances of all metals increase with rise in temperature. The resistances of liquid conductors, on the other hand, usually decrease with rise in temperature. Carbon and a few other solids show a similar behavior: the filament in an incandescent lamp has only about half the resistance when hot that it has when cold. The resistances of wires of the same material are found to be directly proportional to their lengths, and inversely proportional to their cross-sections.

Fig. 10. Exact Size of No. 7 Copper Wire

Ohm's Law. In 1827, Ohm announced the discovery that *the currents furnished by different galvanic cells, or combinations of cells, are always directly proportional to the e. m. f.'s existing in the circuits in which the currents flow, and inversely proportional to the total resistances of these circuits;* that is, if C represents the current in amperes, E the e. m. f. in volts, and R the resistance of the circuit in ohms, then Ohm's law as applied to the complete circuit is

$$C = \frac{E}{R};\ i.\ e.,\ current = \frac{electromotive\ force}{resistance}$$

As applied to any portion of an electrical circuit, Ohm's law is

$$C = \frac{pd}{r};\ i.\ e.,\ current = \frac{potential\ difference}{resistance}$$

where pd represents the difference of potential in volts between any two points in the circuit, and r the resistance in ohms of the conductor connecting these two points. This is one of the most important laws in physics.

Both of the above statements of Ohm's law are included in the equation

$$amperes = \frac{ohms}{volts}$$

Internal Resistance of a Galvanic Cell. If the zinc and copper plates of a simple cell are connected to an ammeter, and the distance between the plates then increased, the deflection of the needle is found to decrease, or if the amount of immersion is decreased the current also will decrease. But since the e. m. f. of a cell has been shown to be wholly independent of the area of the plates immersed or of the distance between them, it will be seen from Ohm's law that the change in the current in these cases must be due to some change in the total resistance of the circuit. Since the wire which constitutes the outside portion of the circuit has remained the same, we must conclude that *the liquid within the cell, as well as the external wire, offers resistance to the passage of the current.* This internal resistance of the liquid is directly proportional to the distance between the plates, and inversely proportional to the area of the immersed portion of the plates. If, then, we represent the external resistance of the circuit of a galvanic cell by R_e and the internal by R_i then Ohm's law as applied to the entire circuit takes the form

$$C = \frac{E}{R_e + R_i}$$

Thus, if a simple cell has an internal resistance of 2 ohms and an e. m. f. of 1 volt, the current which will flow through the circuit when its terminals are connected by 9.3 feet of No. 30 copper wire (1 ohm) is $\frac{1}{1+2} =$ 33 ampere. This is about the current which is usually obtained from an ordinary Daniell cell.

PRIMARY CELLS

Action of a Simple Cell. If the simple cell already mentioned —namely, zinc and copper strips in dilute sulphuric acid—is carefully observed, it will be seen that, so long as the plates are not connected by a conductor, fine bubbles of gas are slowly formed at the zinc plate, but none at the copper plate. As soon, however, as the two strips are put into electrical connection, bubbles instantly appear in great numbers about the copper plate and at the same time a current manifests itself in the connecting wire, Fig. 11. The bubbles are of hydrogen. Their original appearance on the zinc plate may be prevented either by using a plate of chemically pure zinc, or by amalgamating impure zinc, that is, by coating it over with a thin film of mercury. But the bubbles on the copper cannot be thus disposed of. They are an invariable accompaniment of the current in the circuit. If the current is allowed to run for a considerable time, it will be found that the zinc wastes away, even though it has been amalgamated, but the copper plate does not undergo any change.

An electrical current in a simple cell is, then, accompanied by the eating up of the zinc plate by the liquid, and by the evolution of hydrogen bubbles at the copper plate. In every type of galvanic cell, actions similar to these two are always found, that is, *one of the plates is always eaten up, and on the other some element is deposited.* The plate which is eaten is always the one which is found to be negatively charged, while the other is always found to be positively charged; so that in all galvanic cells, when the terminals are connected through a wire, the positive electricity flows through this wire from the uneaten plate to the eaten plate. It will be remembered that the direction in which the *positive* electricity flows is taken for convenience as the direction of the current.

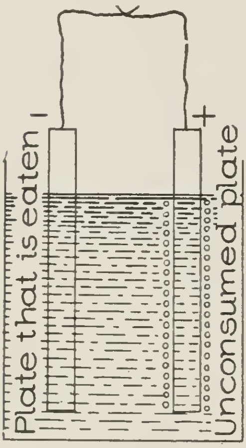


Fig. 11. Action of a Simple Cell

Theory of Action of a Simple Cell. A simple cell may be made of any two dissimilar metals immersed in a solution of any acid or salt. For simplicity, let us examine the action of a cell composed of plates of zinc and copper immersed in a dilute solution of hydrochloric acid. The chemical formula for hydrochloric acid is HCl. This means that each molecule of the acid consists of one atom of hydrogen combined with one atom of chlorine. In accordance with the theory now in vogue among physicists and chemists, when hydrochloric acid is mixed with water so as to form a dilute solution, the HCl molecules split up into two electrically charged parts, called *ions*, the hydrogen ion carrying a positive charge and the chlorine ion an equal negative charge, Fig. 12. This phenomenon is known as *dissociation*. The solution as a whole is neutral, *i. e.*, it is uncharged, because it contains just as many positive as negative ions.

When a zinc plate is placed in such a solution, the acid attacks it and pulls zinc atoms into solution. Now, whenever a metal dissolves in an acid, its atoms, for some unknown reason, go into solution bearing little positive charges. *The corresponding negative charges must be left on the zinc plate* in precisely the same way in which a negative charge is left on silk when positive electrification is produced on a glass rod by rubbing it with the silk. It is in this way, then, that we attempt to account for the negative charge which we find upon the zinc plate in the experiment illustrated in Fig. 4.

The passage of positively charged zinc ions into solution gives a positive charge to the solution about the zinc plate, so that the hydrogen ions tend to be repelled toward the copper plate. When these repelled hydrogen ions reach the copper plate some of them give up their charges to it and then collect as bubbles of hydrogen gas. It is in this way that we account for the positive charge which we find on the copper plate in the experiment illustrated in Fig. 4.

If the zinc and copper plates are not connected by an outside conductor, this passage of positively charged zinc ions into solution continues but a very short time, for the zinc soon becomes so strongly charged negatively that it pulls back on the plus zinc ions with as much force as the acid pulls them into solution. In precisely the same way the copper plate soon ceases to take up any more positive electricity from the hydrogen ions, since it soon acquires a large enough plus charge to repel them from itself with a force equal to that with which they are being driven out of solution by the positively charged zinc ions. It is in this way that we account for the fact that on open circuit no chemical action goes on in the simple galvanic cell, the zinc and copper plates simply becoming charged to a definite difference of potential which is called the e. m. f. of the cell.

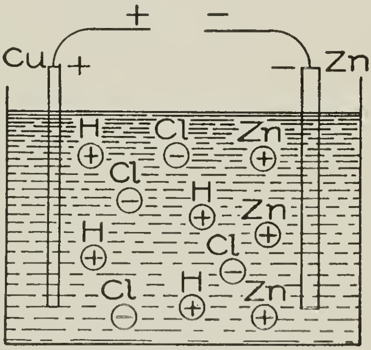


Fig. 12. Dissociation of Ions in Simple Cell

When, however, the copper and zinc plates are connected by a wire, a current at once flows from the copper to the zinc, and the plates thus begin to lose their charges. This allows the acid to pull more zinc into solution at the zinc plate, and allows more hydrogen to go out of solution at the copper plate. These processes, therefore, go on continuously so long as the plates are connected. Hence, a continuous current flows through the connecting wire until the zinc is all eaten up or the hydrogen ions have all been driven out of the solution, *i. e.*, until either the plate or the acid has become exhausted.

Polarization. If the simple cell, which has been described, is connected to an ammeter and the deflection observed for a few minutes, it is found to produce a current of continually decreasing strength; but if the hydrogen is removed from the copper plate by taking out the plate and drying it, the deflection returns to its first value. This phenomenon is called *polarization.*

The presence of the hydrogen on the positive plate causes a diminution in the strength of the current for two reasons: *First,* since hydrogen is a non-conductor, by collecting on the plate it diminishes the effective area of the plate and, therefore, increases the internal resistance of the cell; *second,* by collecting upon the copper plate it lowers the e. m. f. of the cell, because it virtually substitutes a hydrogen plate for the copper plate, and we have already seen that a change in any of the materials of which a cell is composed changes its e. m. f.

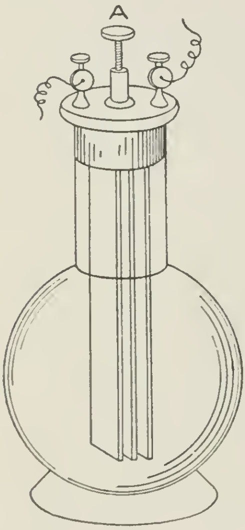


Fig. 13. Bichromate Cell

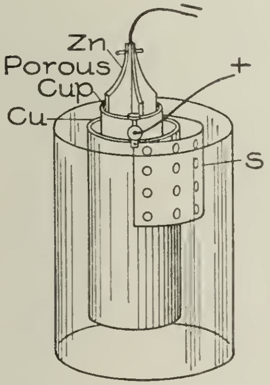
The different forms of galvanic cells in common use differ chiefly in different devices employed either for disposing of the hydrogen bubbles or for preventing their formation. The most common types of such cells are described in the following sections.

Bichromatic Cell. The bichromate cell, Fig. 13, consists of a plate of zinc immersed in sulphuric acid between two plates of carbon, carbon being used instead of copper because it gives a greater e. m. f. In the sulphuric acid is dissolved some bichromate of potassium or sodium, the function of which is to unite chemically with the hydrogen as fast as it is formed at the positive plate, thus preventing its accumulation upon this plate.* Such a cell has the high e. m. f. of 2.1 volts. Its internal resistance is low—from .2 to .5 ohm—since the plates are generally large and close together. It will be seen, therefore, that when the external resistance is very small it is capable of furnishing a current of from 5 to 10 amperes. Since, however, the chromic acid formed by the union of the sulphuric acid with the bi-

*To set up a bichromate cell, dissolve 12 parts, by weight, of sodium bichromate in 180 parts of boiling water. After cooling, add 25 parts of commercial sulphuric acid.

chromate attacks the zinc even when the circuit is open, it is necessary to lift the zinc from the liquid by the rod *A*, when the cell is not in use. Such cells are useful where large currents are needed for a short time. The great disadvantages are that the fluid deteriorates rapidly, and that the zinc cannot be left in the liquid.

Daniell Cell. The Daniell cell consists of a zinc plate immersed in zinc sulphate, and a copper plate immersed in copper sulphate, the two liquids being kept apart either by means of a porous earthen cup, as in the types shown in Fig. 14, or else by gravity, as in the type shown in Fig. 15. This last type, commonly called the *gravity*, or



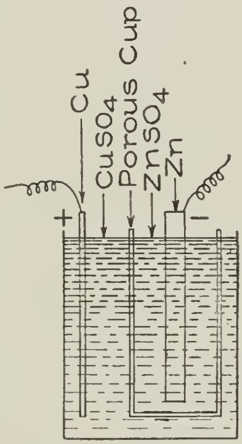


Fig. 14. Section of Daniell Cell Danie'l Cell (Commercial Type)

crowfoot type, is used almost exclusively on telegraph lines. The copper sulphate, being the heavier of the two liquids, remains at the bottom about the copper plate, while the zinc sulphate remains at the top about the zinc plate.

In this cell polarization is almost entirely avoided, for the reason that no opportunity is given for the formation of hydrogen bubbles. For, just as the hydrochloric acid solution consists of positive hydrogen ions and negative chloride ions in water, so the zinc sulphate ($ZnSO_4$) solution consists of positive zinc ions and negative SO_4 ions. Now the zinc of the zinc plate goes into solution in the zinc sulphate in precisely the same way that it goes into solution in the hydrochloric acid of the simple cell. This gives a positive charge to the solution about the zinc plate, and causes a movement of the positive ions between the two plates from the zinc toward the copper, and of negative ions in the opposite direction, both the Zn and the SO_4 ions being able to pass through the porous cup. Since the positive ions about the copper plate consist of atoms of copper, it will be seen that the material which is driven out of solution at the copper plate, instead of being hydrogen, as in the simple cell, is metallic copper. Since, then, the element which is deposited on the copper plate is of the same molecular structure as that of which it already consists, it is clear that neither the electromotive force nor the resistance of the cell can be changed by the presence of this deposit, *i. e.*, the cause of the polarization of the simple cell has been removed.

The great advantage of the Daniell cell lies in the relatively high degree of constancy in its e. m. f. (1.08 volts). It has a comparatively high internal resistance—one to six ohms—and is, therefore, incapable of producing very large currents, about one ampere at most. It will furnish a very constant current, however, for a great length of time; in fact until all of the copper is driven out of the copper sulphate solution. In order to keep a constant supply of the copper ions in the solution, copper sulphate crystals are kept in the compartment S of the cell of Fig. 14, or in the bottom of the gravity cell. These dissolve as fast as the solution loses its strength through the deposition of copper on the copper plate.

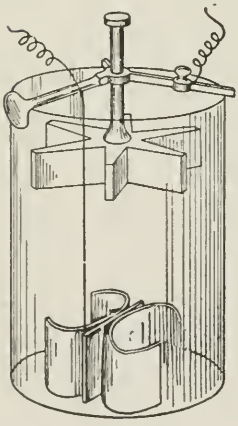


Fig. 15. Gravity Cell

The Daniell is a so-called *closed-circuit* cell, *i. e.*, its circuit should be left closed—through a resistance of thirty or forty ohms—whenever the cell is not in use. If it is left on open circuit, the copper sulphate diffuses through the porous cup, and a brownish muddy deposit of copper or copper oxide is formed upon the zinc. Pure copper is also deposited in the pores of the porous cup. Both of these actions damage the cell. When the circuit is closed, however, since the electrical forces always keep the copper ions moving toward the copper plate, these damaging effects are to a large extent avoided

Leclanché Cell. The Leclanché cell, Fig. 16, consists of a zinc rod in a solution of ammonium chloride—150 g. to a liter of water—and a carbon plate placed inside of a porous cup which is packed full of manganese dioxide and powdered graphite or carbon. As in the simple cell, the zinc dissolves in the liquid, and hydrogen is liberated at the carbon, or positive, plate. Here it is slowly attacked by the manganese dioxide. This chemical action is, however, not quick enough to prevent rapid polarization when large currents are taken from the cell. The cell slowly recovers when allowed to stand for a while on open circuit. The e. m. f. of a Leclanché cell is about 1.5 volts, and its initial internal resistance is somewhat less than an ohm. It, therefore, furnishes a momentary current of from one to three amperes.

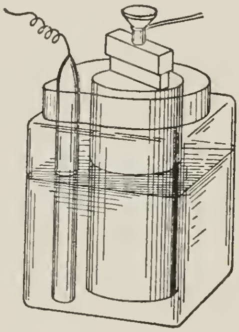


Fig. 16. Leclanché Cell

The immense advantage of this type of cell lies in the fact that the zinc is not at all eaten by the ammonium chloride when the circuit is open, and that, therefore, unlike the Daniell or bichromate cells, it can be left for an indefinite time on open circuit without deterioration. Leclanché cells are used almost exclusively where momentary currents only are needed, as, for example, on door-bell circuits. The cell requires no attention for years at a time, other than the occasional addition of water to replace loss by evaporation, and the occasional addition of ammonium chloride (NH_4Cl) to keep positive NH_4 and negative Cl ions in the solution.

Dry Cell. The dry cell is only a modified form of the Leclanché cell. It is not really *dry*, since the zinc and carbon plates are imbedded in moist paste which consists usually of one part of crystals of ammonium chloride, three parts of plaster of Paris, one part of zinc oxide, one part of zinc chloride, and two parts of water. The plaster of Paris is necessary in order to give the paste the required rigidity. As in the Leclanché cell, the current is produced by the chemical action of the ammonium chloride upon the zinc plate which forms the outside wall of the cell.

Combinations of Cells. There are two ways in which cells may be combined: *First*, in series; and *second*, in parallel. When they are connected in series the zinc of one cell is joined to the copper of the second, the zinc of the second to the copper of the third, etc., the copper of the first and the zinc of the last being joined to the ends of the external resistance, Fig. 17. The e. m. f. of such a combination is the sum of the e. m. f.'s of the single cells. The internal resistance of the combination is also the sum of the internal resistances of the single cells. Hence, if the external resistances are very small, the current furnished by the combination will not be larger than that furnished by a single cell, since the total resistance of the circuit has been increased in the same ratio as the total e. m. f. But if the ex-

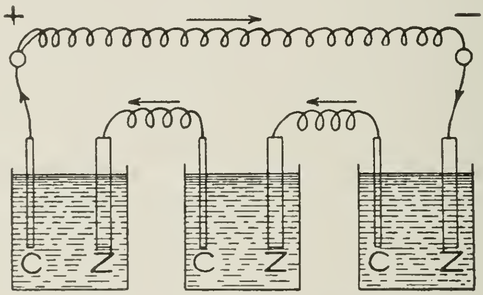


Fig. 17. Cells Connected in Series

ternal resistance is large, the current produced by the combination will be very much greater than that produced by a single cell. Just how much greater can always be determined by applying Ohm's law, for if there are n cells in series, and E is the e. m. f. of each cell, the total e. m. f. of the circuit is $n\ E$. Hence if R_e is the external resistance and R_i the internal resistance of a single cell, then Ohm's law gives

$$C = \frac{nE}{R_e + nR_i}$$

If the n cells are connected in parallel, that is, if all the coppers are connected together and all the zincs, as in Fig. 18, the e. m. f. of the combination is only the e. m. f. of a single cell, while the internal resistance is $\frac{1}{n}$ of that of a single cell, since connecting the cells in this way is simply equivalent to multiplying the area of the plates n times. The current furnished by such a combination will be given by the formula

$$C = \frac{E}{R_e + \frac{R_i}{n}}$$

If, therefore, R_e is negligibly small, as in the case of a heavy copper wire, the current flowing through it will be n times as great as that which could be made to flow through it by a single cell. These considerations show that the rules which should govern the combination of cells are as follows:

When the external resistance is large in comparison with the internal resistance of a single cell, the cells should be connected in series.

When the external resistance is small in comparison with the internal resistance of a single cell, the cells should be connected in parallel.

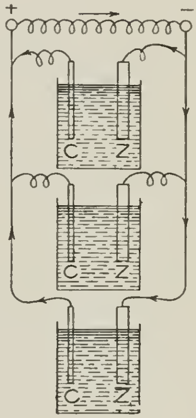


Fig. 18. Cells Connected in Parallel

Storage Battery. If two lead plates are immersed in sulphuric acid and the current sent through the cell, the anode or plate at which the current enters the solution will be found in the course of a few minutes to turn dark brown. This brown coat is a compound of lead with the oxygen which, in the case of the platinum electrodes, was evolved as a gas. The other lead plate is not affected by the hydrogen, which is, in this case, as in that of the platinum, evolved as a gas. Since the passage of the current through this cell has left one plate unchanged, while it has changed the surface of the other plate to a new substance, namely, lead peroxide, PbO_2, it might be expected that if the charging battery were removed, and these two dissimilar plates connected with a wire, a current will flow through the wire, for the arrangement is now essentially a simple galvanic cell, which in its essentials consists simply of two dissimilar plates immersed in an electrolyte—a conducting liquid other than a molten metal. In this case the plate having the lead peroxide upon it corresponds to the copper of an ordinary cell, and the unchanged lead plate to the zinc. The arrangement will furnish a current until the lead peroxide is all used up. The only important difference between a commercial storage cell and the two lead plates just considered, is that the former is provided in the process of manufacture with a very much thicker coat of the *active material*—lead peroxide on the positive plate, and a porous, spongy lead on the negative—than can be formed by a single charging such as we considered. In one type of storage cell this active material is actually formed by the repeated charging and discharging of plates which are originally ordinary sheets of lead. With each new charging a slightly thicker layer of the lead peroxide is formed. In the more common type of commercial cell the active material is pressed into interstices of the plate in the form of a paste. It will be seen from this discussion that a storage battery is not, properly speaking, a device for storing electricity. It is rather a device in which the electrical current produces chemical changes, and these new chemicals, so long as they last, are capable of generating a new electrical current.

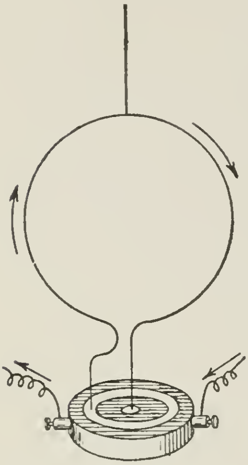


Fig. 19. Magnetic Properties of a Loop

ELECTROMAGNETISM

Magnetic Properties of a Loop. We have seen that an electrical current is surrounded by a magnetic field the direction of which is given by the right-hand rule. We have seen also that a loop or coil of wire through which a current flows produces a magnetic field of the shape shown in Fig. 7. Now, if such a loop is suspended in the manner shown in Fig. 19 while a current is passed through it, it is found to slowly set itself in an east-and-west plane, and so that the face of the loop from which the magnetic lines emerge, Fig. 20, is toward the north. In other words, the loop will be found to behave with respect

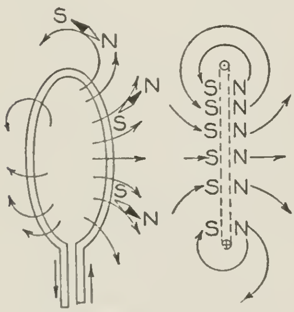


Fig 20. Magnetic Properties of a Loop

to the earth or to any other magnet precisely as though it were a flat magnetic disk whose boundary is the wire, the face which turns toward the north, that is, that from which the magnetic lines emerge, being an N pole and the other an S pole.

Magnetic Properties of a Helix. If a wire carrying a current be wound in the form of a helix and held near a suspended magnet

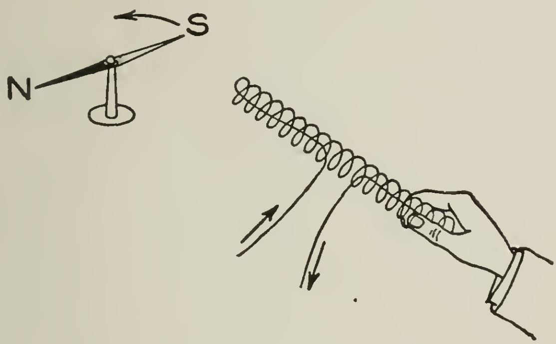


Fig. 21. Magnetic Properties of a Helix

as in Fig. 21, the coil will be found to act in every respect like a magnet, with an N pole at one end and an S pole at the other.

This result might have been predicted from the fact that a single loop is equivalent to a flat-disk magnet. For when a series of such disks is placed side by side, as in the helix, the result must be the

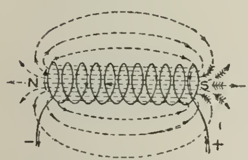


Fig. 22. Magnetic Field About a Helix

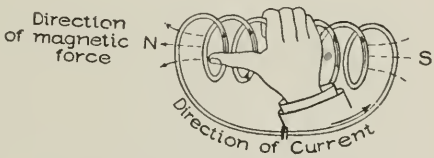


Fig. 23. Right-Hand Rule for a Helix

same as placing a series of disk magnets in a row, the N pole of one being directly in contact with the S pole of the next, etc. These poles would, therefore, all neutralize each other except at the two ends. We, therefore, get a magnetic field of the shape shown in Fig. 22, the direction of the arrows representing as usual the direction in which an N pole tends to move.

Rules for North and South Poles of a Helix. The right-hand rule as already given is sufficient in every case to determine which is the N and which the S pole of a helix, *i. e.,* from which end the lines of magnetic force emerge from the helix and at which end they enter it. But it is found convenient, in the consideration of coils, to restate the right-hand rule in a slightly different way, Fig. 23, thus:

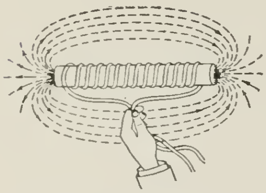


Fig. 24. A Simple Electromagnet and Its Field

If the coil is grasped in the right hand in such a way that the fingers point in the direction in which the current is flowing in the wires, the thumb will point in the direction of the north pole of the helix.

Similarly, if the sign of the poles is known, but the direction of the current unknown, the latter may be determined as follows:

If the right hand is placed against the coil with the thumb pointing in the direction of the lines of force, i. e., toward the north pole of the helix, the fingers will pass around the coil in the direction in which the current is flowing.

Electromagnet. If a core of soft iron be inserted in the helix, Fig. 24, the poles will be found to be enormously stronger than before. This is because the core is magnetized by induction from the field of

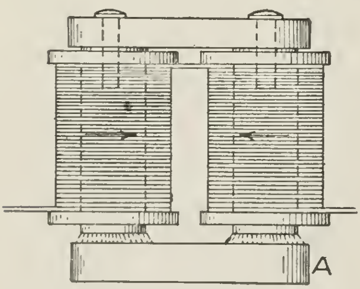


Fig. 25. Horseshoe Electromagnet with Armature

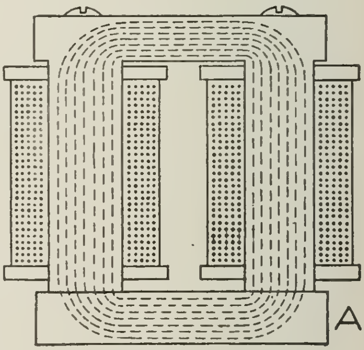


Fig. 26. Field of Horseshoe Electromagnet

the helix in precisely the same way in which it would be magnetized by induction if placed in the field of a permanent magnet. The new field strength about the coil is now the sum of the fields due to the core and that due to the coil. If the current is broken, the core will at once lose the greater part of its magnetism. If the current is re-

SCENE FROM "POEMS IN PICTURES," BY GAUMONT
A Series of Imaginative Conceptions Which Deeply Impressed the Artistic Element of the Country
Courtesy of the *Kleine Optical Co., Chicago*

THE PRINCE FINDS LITTLE SNOWWHITE
Scene from Pathé film, "Little Snowwhite"
Courtesy of *Pathé Frères, New York and Paris*

versed, the polarity of the core will be reversed. Such a coil with a soft-iron core is called an *electromagnet.*

The strength of an electromagnet can be very greatly increased by giving it such form that the magnetic lines can remain in iron throughout their entire length instead of emerging into air, as they do in Fig. 24. For this reason electromagnets are usually built in the horseshoe form and provided with an armature A, Fig. 25, through which a complete iron path for the lines of force is established as shown in Fig. 26. The strength of such a magnet depends

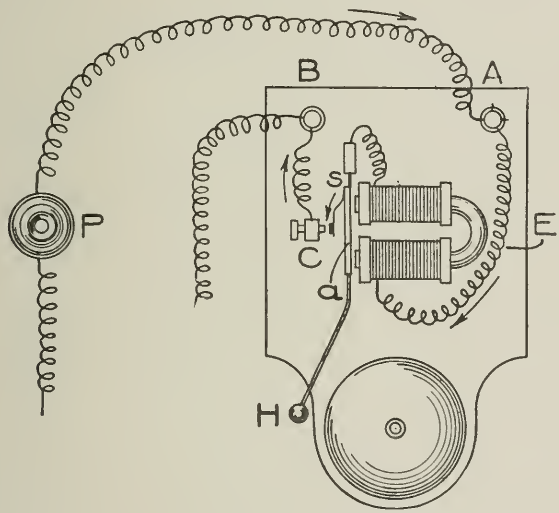


Fig. 27. Simple Electric Bell and Connections

chiefly upon the number of *ampere-turns* which encircle it, the expression *ampere-turns* denoting the product of the number of turns of wire about the magnet by the number of amperes flowing in each turn. Thus a current of $\frac{1}{100}$ ampere flowing 1,000 times around a core will make an electromagnet of precisely the same strength as a current of 1 ampere flowing 10 times about the core.

Electric Bell. The electric bell, Fig. 27, is one of the simplest applications of the electromagnet. When the button P is pressed, the electric circuit of the battery is closed and a current flows in at A, through the magnet, over the closed contact C, and out again at B. But no sooner is this current established than the electromagnet E pulls over the armature a, and in so doing breaks the contact at C.

This stops the current and demagnetizes the magnet *E*. The armature is then thrown back against *C* by the elasticity of the spring *s* which supports it. No sooner is the contact made at *C* than the current again begins to flow and the former operation is repeated. Thus the circuit is automatically made and broken at *C* and the hammer *H* is, in consequence, set into rapid vibration against the rim of the bell.

LAWS OF CURRENT FLOW

RESISTANCE

All substances resist the passage of electricity, but the resistance offered by some is very much greater than that offered by others. Metals have by far the least resistance and, of these, silver possesses the least of any. In other words, silver is the best conductor. If the temperature remains the same, the resistance of a conductor is not affected by the current passing through it. A current of ten, twenty, or any number of amperes may pass through a circuit, but its resistance will be unchanged with constant temperature. Resistance is affected by the temperature and also by the degree of hardness. Annealing decreases the resistance of a metal.

Conductance. Conductance is the inverse of resistance, that is, if a conductor has a resistance of R ohms, its conductance is equal to $\frac{1}{R}$.

Resistance Proportional to Length. The resistance of a conductor is directly proportional to its length. Hence, if the length of a conductor is doubled, the resistance is doubled, or if the length is divided, say into three equal parts, then the resistance of each part is one-third the total resistance.

Example. The resistance of 1,283 feet of a certain wire is 6.9 ohms. What is the resistance of 142 feet of the same wire?

Solution. As the resistance is directly proportional to the length we have the proportion

$$\textit{required resistance} : 6.9 :: 142 : 1283$$

or,

$$\frac{\textit{required resistance}}{6.9} = \frac{142}{1283}$$

Hence,

$$\textit{required resistance} = 6.9 \times \frac{142}{1283}$$

$$= .76 \text{ ohm (approx.)}$$

Ans. .76 ohm.

EXAMPLE. The resistance of a wire having a length of 521 feet is .11 ohm. What length of the same wire will have a resistarce of .18 ohm?

Solution. As the resistance is proportional to length, we have the proportion

$$\textit{required length} : 521 :: .18 : .11$$

or,

$$\frac{\textit{required length}}{521} = \frac{.18}{.11}$$

Hence,

$$\textit{required length} = 521 \times \frac{.18}{.11}$$

$$= 852 \text{ feet (approx.)}$$

Ans. 852 feet.

Resistance Inversely Proportional to Cross-Section. The resistance of a conductor is inversely proportional to its cross-sectional area. Hence the greater the cross-section of a wire the less is its resistance. Therefore, if two wires have the same length, but one has a cross-section three times that of the other, the resistance of the former is one-third that of the latter.

EXAMPLE. The ratio of the cross-sectional area of one wire to that of another of the same length and material is $\frac{257}{101}$. The resistance of the former is 16.3 ohms. What is the resistance of the latter?

Solution. As the resistances are inversely proportional to the cross-sections, the smaller wire has the greater resistance, and we have the proportion

$$\textit{required resistance} : 16.3 :: 257 : 101$$

or,

$$\frac{\textit{required resistance}}{16.3} = \frac{257}{101}$$

Hence,

$$\textit{required resistance} = 16.3 \times \frac{257}{101}$$

$$= 41.5 \text{ ohms (approx.)}$$

Ans. 41.5 ohms.

EXAMPLE. If the resistance of a wire of a certain length and having a cross-sectional area of .0083 square inch is 1.7 ohms, what would be its resistance if the area of its cross-section were .092 square inch?

Solution. Since increasing the cross-sectional area of a wire decreases its resistance, we have the proportion

$$\textit{required resistance} : 1.7 :: .0083 : .092$$

or,

$$\frac{\textit{required resistance}}{1.7} = \frac{.0083}{.092}$$

Hence,

$$\textit{required resistance} = 1.7 \times \frac{.0083}{.092}$$

$$= .15 \text{ ohm (approx.)}$$

Ans. .15 ohm.

As the area of a circle is proportional to the square of its diameter, it follows that the resistance of round conductors are inversely proportional to the squares of their diameters.

EXAMPLE. The resistance of a certain wire having a diameter of .1 inch is 12.6 ohms. What would be its resistance if the diameter were increased to .32 inch?

Solution. The resistances being inversely proportional to the squares of the diameters, we have

$$\textit{required resistance} : 12.6 : : .1^2 : .32^2$$

or,

$$\frac{\textit{required resistance}}{12.6} = \frac{.1^2}{.32^2}$$

Hence,

$$\textit{required resistance} = 12.6 \times \frac{.1^2}{.32^2}$$

$$= \frac{12.6 \times .01}{.1024}$$

$$= 1.23 \text{ ohms (approx.)}$$

Ans. 1.23 ohms.

Specific Resistance. The specific resistance of a substance is the resistance of a portion of that substance of unit length and unit cross-section at a standard temperature. The units commonly used are the centimeter of the inch, and the temperature that of melting ice. The specific resistance may therefore be said to be the resistance (usually stated in microhms) of a centimeter cube or of an inch cube at the temperature of melting ice. If the specific resistances of two substances are known, then their relative resistance is given by the ratio of the specific resistances.

Conductivity. Conductivity is the reciprocal of specific resistance.

EXAMPLE. A certain copper wire at the temperature of melting ice has a resistance of 29.7 ohms. Its specific resistance--resistance of 1 centimeter cube in microhms—is 1.594, and that of platinum is 9.032. What would be the resistance of a platinum wire of the same size and length of the copper wire, and at the same temperature?

Solution. The resistance would be in direct ratio of the specific resistances, and we have the proportion

$$\textit{required resistance} : 29.7 : : 9.032 : 1.594$$

Hence,

$$\textit{required resistance} = 29.7 \times \frac{9.032}{1.594}$$

$$= 168 \text{ ohms (approx.)}$$

Ans. 168 ohms.

Calculation of Resistance. From the preceding pages it is evident that resistance varies directly as the length, inversely as the cross-sectional area, and depends upon the specific resistance of the material. This may be expressed conveniently by the formula

$$R = s\frac{L}{A}$$

in which R is the resistance, L the length of the conductor, A the area of its cross-section, and s the specific resistance of the material.

EXAMPLE. A telegraph relay is wound with 1,800 feet of wire .010 inch in diameter, and has a resistance of 150 ohms. What will be its resistance if wound with 400 feet of wire .022 inch in diameter?

Solution. If the wires were of equal length, we should have the proportion

$$\textit{required resistance} : 150 : : (.010)^2 : (.022)^2$$

or,

$$\textit{required resistance} = 150 \times \frac{(.010)^2}{(.022)^2} = 30.99 + \text{ ohms}$$

For a wire 400 feet long, we have, therefore, by direct proportion,

$$\textit{required resistance} = \frac{400}{1,800} \times 30.99 = 6.88+$$

Ans. 6.88 + ohms.

If a circuit is made up of several different materials joined in series with each other, the resistance of the circuit is equal to the sum of the resistances of its several parts. In calculating the resistance of such a circuit, the resistance of each part should first be calculated, and the sum of these resistances will be the total resistance of the circuit.

In Table I is given the resistance of chemically pure substances at 0° centigrade or 32° Fahrenheit in International ohms. The first column of numbers gives the relative resistances when that of annealed silver is taken as unity. For example, mercury has 62.73 times the resistance of annealed silver. The second and third columns give the resistances of a foot of wire .001 inch in diameter, and of a meter of wire 1 millimeter in diameter, respectively. The fourth and fifth columns give respectively the resistance in microhms of a cubic inch and cubic centimeter, that is, the specific resistances.

TABLE I

Relative Resistance of Chemically Pure Substances at 32° F. International Ohms

Metals	Relative Resistance	Resistance of a wire 1 foot long .001 in. in diameter	Resistance of a wire 1 m. long 1 mm. in diameter	Resistance in Microhms	
				Cubic Inch	Cubic Centimeter
Silver, annealed	1.000	9.023	.01911	.5904	1.500
Copper, annealed	1.063	9.585	.02028	.6274	1.594
Silver, hard drawn	1.086	9.802	.02074	.6415	1.629
Copper, hard drawn	1.086	9.803	.02075	.6415	1.629
Gold, annealed	1.369	12.35	.02613	.8079	2.052
Gold, hard drawn	1.393	12.56	.02661	.8224	2.088
Aluminum, annealed	1.935	17.48	.03700	1.144	2.904
Zinc, pressed	3.741	33.76	.07143	2.209	5.610
Platinum, annealed	6.022	54.34	.1150	3.555	9.032
Iron, annealed	6.460	58.29	.1234	3.814	9.689
Lead, pressed	13.05	117.7	.2491	7.706	19.58
German silver	13.92	125.5	.2659	8.217	20.87
Platinum-silver alloy ($\frac{1}{3}$ platinum, $\frac{2}{3}$ silver)	16.21	146.3	.3097	9.576	24.32
Mercury	62.73	570.7	1.208	37.05	94.06

A very small portion of foreign matter mixed with a metal greatly increases its resistance. An alloy of two or more metals always has a higher specific resistance than that of any of its constituents. For example, the conductivity of silver mixed with 1.2 per cent in volume of gold, will be 59 when that of pure silver is taken as 100. Annealing reduces the resistance of metals.

The following examples are given to illustrate the use of Table I in connection with the formula $R = s\frac{L}{A}$ and to show the application of preceding laws.

Example. From the specific resistance of annealed aluminum as given in the next to the last column of the table, calculate the resistance given in the second column of figures for that substance.

Solution. The resistance in microhms of a cubic inch of annealed aluminum at 32° F. is 1.144, which is equal to .000001144 ohms. The resistance of a wire 1 foot long and .001 inch in diameter is required. According to the formula $s = .000001144$, $L = 1$ foot $= 12$ inches and

$$A = \frac{\pi d^2}{4} = \frac{3.1416 \times .001^2}{4} = .0000007854 \text{ sq. in.}$$

Substituting these values in the formula

$$R = s\frac{L}{A}$$

we have

$$R = .000001144 \times \frac{12}{.0000007854}$$
$$= 17.48 \text{ ohms}$$

Ans. 17.48 ohms.

Example. The resistance in microhms of a cubic centimeter of annealed platinum at 32° F. is 9.032. What is the resistance of a wire of the same substance one meter long and one millimeter in diameter at the same temperature?

Solution. In the formula for resistance we have the quantities $s =$ 9.032 microhms = .000009032 ohms; L = 1 meter = 100 centimeters; and

$$A = \frac{\pi d^2}{4} = \frac{3.1416 \times .1^2}{4} = .007854 \text{ sq. cm.}$$

the diameter being equal to 1 millimeter = .1 cm.

Substituting these values we have

$$R = .000009032 \times \frac{100}{.007854}$$
$$= .115 \text{ ohm}$$

Ans. .115 ohm.

Example. From Table I the resistance of 1 foot of pure annealed silver wire .001 inch in diameter at 32° F. is 9.023 ohms. What is the resistance of a mile of wire of the same substance .1 inch in diameter at that temperature?

Solution. As the resistance of wires is directly proportional to their length and inversely proportional to the squares of their diameters, the required resistance is found by multiplying the resistance per foot by 5,280 and the product by the inverse squares of the diameters.

$$\text{Therefore, } R = 9.023 \times 5280 \times \left\{\frac{.001}{.1}\right\}^2$$
$$= 4.76 \text{ ohms (approx.)}$$

Ans. 4.76 ohms.

Example. A mile and one-half of an annealed wire of pure iron has a resistance of 46.1 ohms. What would be the resistance of hard-drawn wire of pure copper of the same length and diameter, assuming each to be at the temperature of melting ice?

Solution. The only factor involved by this example is the relative resistance of the two metals. From Table I, annealed iron has 6.460 and hard-drawn copper 1.086 times the resistance of annealed silver. Hence, the resistance of the copper is to that of the iron as 1.086 is to 6.460, and the required resistance is

$$R = 46.1 \times \frac{1.086}{6.460} = 7.75 \text{ ohms (approx.)}$$

Ans. 7.75 ohms.

Example. If the resistance of a wire 7,423 feet long is 18.7 ohms, what would be its resistance if its length were reduced to 6,253 feet and its cross-section made one half again as large?

Solution. As resistance is directly proportional to the length, and inversely proportional to the area of the cross-section, the required resistance is

$$R = 18.7 \times \frac{6253}{7423} \times \frac{2}{3} = 10.5 \text{ ohms (approx.)}$$

Ans. 10.5 ohms.

Resistance Affected by Heating. The resistance of metals depends upon the temperature, and the resistance is increased by heating. The heating of some substances, among which is carbon, causes a decrease in their resistance. The resistance of the filament of an incandescent lamp when lighted is only about half as great as when cold. All *metals*, however, have their resistance increased by a rise in temperature. The percentage increase in resistance with rise of temperature varies with the different metals, and varies slightly for the same metal at different temperatures. The increase is practically uniform for most metals throughout a considerable range of temperature. The resistance of copper increases about .4 per cent per degree centigrade, or about .22 per cent degree Fahrenheit. The percentage increase in resistance for alloys is much less than for the simple metals. Standard resistance coils are, therefore, made of alloys, as it is desirable that their resistance should be as nearly constant as possible.

The change in resistance of one ohm per degree rise in temperature for a substance is called the *temperature coefficient* for that substance. Table II gives the temperature coefficients for a few substances.

If the resistance of a conductor at a certain temperature is known, the resistance the conductor will have at a higher temperature may be found by multiplying the temperature coefficient for the substance, by the number of degrees increase and by the resistance at the lower temperature, and adding to this result the resistance at the lower temperature. The product of the temperature coefficient by the number of degrees increase gives the increase in resistance of one ohm through that number of degrees, and multiplying this by the number of ohms gives the increase in resistance for the conductor. The result obtained is practically correct for moderate ranges of temperature.

TABLE II

Temperature Coefficients

MATERIAL	RISE IN R. OF 1 OHM WHEN HEATED	
	1° F.	1° C.
Platinoid	.00012	.00022
Platinum-silver	.00014	.00025
German silver	.00022	.00040
Platinum	.0019	.0035
Silver	.0021	.0038
Copper, aluminum	.0022	.0040
Iron	.0026	.0046

The above method of calculating the resistance of conductors at increased temperature is conveniently expressed by the following formula

$$R_2 = R_1\,(1 + at)$$

where R_2 is the resistance at the higher temperature, R_1 that at the lower temperature, a the temperature coefficient for the substance, and t the number of degrees change.

From the preceding formula it follows that if the resistance at the higher temperature is known, that at the lower temperature will be given by the formula

$$R_1 = \frac{R_2}{1 + at}$$

In calculating resistances at different temperatures, the temperature coefficient based on the Fahrenheit scale should be used if the number of degrees change is given in degrees Fahrenheit, and that based on the centigrade scale if given in degrees centigrade.

EXAMPLE. The resistance of a coil of German silver wire at 12° C. is 1,304 ohms. What would be its resistance at a temperature of 60° C.?

Solution. From the statement of the example R_1 = 1,304, t = 60 − 12 = 48, and from Table II, a = .0004. Substituting these values in the formula $R_2 = R_1\,(1 + at)$, we have

$$R_1 = 1304\,(1 + .0004 \times 48)$$
$$= 1304 \times 1.0192$$
$$= 1329 \text{ ohms (approx.)}$$

Ans. 1329 ohms.

TABLE III

American Wire Gauge (B. & S.)

No.	Diameter in Mils	Diameter in Millim.	Circular Mils	Ohms per 1000 Ft.	No.	Diameter in Mils	Diameter in Millim.	Circular Mils	Ohms per 1000 Ft.
0000	460.00	11.684	211600.0	.051	19	35.89	.912	1288.0	8.617
000	409.64	10.405	167805.0	.064	20	31.96	.812	1021.5	10.566
00	364.80	9.266	133079.4	.081	21	28.46	.723	810.1	13.323
0	324.95	8.254	105592.5	.102	22	25.35	.644	642.7	16.799
1	289.30	7.348	83694.2	.129	23	22.57	.573	509.5	21.185
2	257.63	6.544	66373.0	.163	24	20.10	.511	404.0	26.713
3	229.42	5.827	52634.0	.205	25	17.90	.455	320.4	33.684
4	204.31	5.189	41742.0	.259	26	15.94	.405	254.0	42.477
5	181.94	4.621	33102.0	.326	27	14.19	.361	201.5	53.563
6	162.02	4.115	26250.5	.411	28	12.64	.321	159.8	67.542
7	144.28	3.665	20816.0	.519	29	11.26	.286	126.7	85.170
8	128.49	3.264	16509.0	.654	30	10.03	.255	100.5	107.391
9	114.43	2.907	13094.0	.824	31	8.93	.277	79.7	135.402
10	101.89	2.588	10381.0	1.040	32	7.95	.202	63.2	170.765
11	90.74	2.305	8234.0	1.311	33	7.08	.108	50.1	215.312
12	80.81	2.053	6529.9	1.653	34	6.30	.160	39.7	271.583
13	71.96	1.828	5178.4	2.084	35	5.61	.143	31.5	342.443
14	64.08	1.628	4106.8	2.628	36	5.00	.127	25.0	431.712
15	57.07	1.450	3256.7	3.314	37	4.45	.113	19.8	544.287
16	50.82	1.291	2582.9	4.179	38	3.96	.101	15.7	686.511
17	45.26	1.150	2048.2	5.269	39	3.53	.090	12.5	865.046
18	40.30	1.024	1624.1	6.645	40	3.14	.080	9.9	1091.865

Example. If the resistance of a copper conductor at 95° F. is 48.2 ohms, what would be the resistance of the same conductor at 40° F.?

Solution. In this case $R_2 = 48.2$, $t = 95 - 40 = 55$, and from Table II, $a = .0022$. Substituting these values in the formula $R_1 = \frac{R_2}{1+at}$ we have

$$R_1 = \frac{48.2}{1 + .0022 \times 55} = \frac{48.2}{1.121}$$

$$= 43 \text{ ohms (approx.)}$$

Ans. 43 ohms.

Table III gives the resistance of the most common sizes of copper wire according to the American or Brown and Sharpe (B. & S.) gauge. The resistance given is for pure copper wire at a temperature of 75° F. or 24° C. The fourth column gives the equivalent number of wires each one mil or one-thousandth of an inch in diameter. This is called the size of the wire in circular mil and is equal to the square of the diameter in mils. The fifth column gives the ohms per thousand feet and the resistance per mile is found by multiplying these values by 5.28. Ordinary commercial copper has a conductivity of about 95 to 97 per cent of that of pure copper. The resistance of commercial wire is, therefore, about 3 to 5 per cent greater than the values given in Table III. The resistance for any metal other than copper may be found by multiplying the resistance given in Table III by the ratio of the specific resistance of the given metal to the specific resistance of copper.

Table IV gives the size of the English or Birmingham wire gauge. The B. & S. is, however, much more frequently used in this country. The Brown and Sharpe gauge is a little smaller than the Birmingham for corresponding numbers.

TABLE IV

Stubs' or Birmingham Wire Gauge (B. W. G.)

No.	Diameter in		No.	Diameter in		No.	Diameter in	
	Mils	Millim.		Mils	Millim.		Mils	Millim.
0000	454	11.53	8	165	4.19	18	49	1.24
00	380	9.65	10	134	3.40	20	35	0.89
1	300	7.62	12	109	2.77	24	22	0.55
4	238	6.04	14	83	2.11	30	12	0.31
6	203	5.16	16	65	1.65	36	4	0.10

EXAMPLES FOR PRACTICE

1. What is the resistance of an annealed silver wire 90 feet long and .2 inch in diameter at 32° F.? Ans. .02+ ohm.

2. What is the resistance of 300 meters of annealed iron wire 4 millimeters in diameter when at a temperature of 0° C.?
Ans. 2.31+ ohms.

3. What is the resistance of 2 miles of No. 27 (B. & S.) pure copper wire at 75° F.? Ans. 565+ ohms.

4. The resistance of a piece of copper wire at 32° F. is 3 ohms. What is its resistance at 49° F.? Ans. 3.11+ ohms.

5. The resistance of a copper wire at 52° F. is 7 ohms. What is its resistance at 32° F.? Ans. 6.70+ ohms.

6. What is the resistance of 496 ft. of No. 10 (B. & S.) pure copper wire at 45° F.? Ans. .483+ ohms.

TABLE V

Primary Cells, Electromotive Force, Resistance, Etc.

Name of Cell	Anode	Kathode	Excitant	Depolarizer	E. M. F. in Volts	Internal Resistance in Ohms
Volta (Wollaston, etc.)	Zinc	Copper	Solution of Sulphuric Acid (H_2SO_4)	None	1 to 0.5	
Smee	Zinc	Platinized Silver	Solution of Sulphuric Acid (H_2SO_4)	None	1 to 0.5	0.5
Law	Zinc	Carbon	Solution of Sulphuric Acid (H_2SO_4)	None	1 to 0.5	
Poggendorff (Grenet)	Zinc	Graphite (Carbon)	Solution of Sulphuric Acid (H_2SO_4)	Potassium Dichromate ($K_2Cr_2O_7$)	2.1	
Poggendorff (Grenet) two fluid	Zinc	Graphite (Carbon)	Saturated Solution of Potassium Dichromate and Sulphuric Acid	None Separate	1.98	.001 to .08
Grove	Zinc	Platinum	Sulphuric Acid dilute (H_2SO_4)	Nitric Acid (HNO_3)	1.96	0.1 to 0.12
Bunsen	Zinc	Graphite (Carbon)	Sulphuric Acid dilute (H_2SO_4)	Nitric Acid Chromic Acid	1.8to1.98 1.8	0.08to0.11 0.1 to 0.12
Leclanché		Graphite (Carbon)	Ammonium Chloride (NH_4Cl)	Manganese Dioxide (MnO_2)	1.4 to 1.6	1.13 to 1.15
Lalande Lalande–Chaperon	Zinc	Graphite (Carbon)	Caustic Potash or Potassium Hydrate (KOH)	Cupric Oxide	0.8 to 0.9	1.3
Upward	Zinc	Graphite (Carbon)	Zinc Chloride ($ZnCl_2$)	Chlorine (Cl)	2.0	
Fitch	Zinc	Graphite (Carbon)	Ammonium Chloride (NH_4Cl)	Sodium&Potassium Chlorates ($NaClO_3$+ $KClO_3$)	1.1	
Papst	Iron	Graphite (Carbon)	Ferric Chloride (Fe_2Cl_6)	[(Fe_2Cl)	0.4	
Obach (dry)	Zinc	Graphite (Carbon)	Ammonium Chloride (NH_4Cl) in Calcium Sulphate ($CaSO_4$)	Manganese Dioxide (MnO_2)	1.46	
Daniell (Meidinger Minotto, etc.)	Zinc	Copper	Zinc Sulphate ($ZnSO_4$)	Copper Sulphate ($CuSO_4$)	1.079	2 to 5
De la Rue	Zinc	Silver	Ammonium Chloride	Silver Chloride (AgCl)	1.03 to 1.42	0.4 to 0.6
Marie Davy	Zinc	Graphite (Carbon)	Sulphuric Acid dilute (H_2SO_4)	Paste of Sulphate of Mercury (Hg_2SO_4)	1 52	0.75 to 1
Clark (Standard)	Zinc	Mercury	Zinc Sulphate ($ZnSo_4$)	Mercurous Sulphate(Hg_2SO_4)	1.434*	0.3 to 0.5
Weston	Cadmium	Mercury	Cadmium Sulphate ($CdSO_4$)	Mercurous Sulphate(Hg_2SO_4)	1.025	

*At 15 degrees centigrade or 59 degrees Fahrenheit.

TABLE V (Continued)

Name of Cell	Anode	Kathode	Excitant	Depolarizer	E. M. F. in Volts	Internal Resistance in Ohms
Von Helmholtz	Zinc	Mercury	Zinc Chloride ($ZnCl_2$)	Mercurous Chloride (Hg_2Cl_2)	1.0	
Chromic Acid single fluid	Zinc	Graphite (Carbon)	Sulphuric and Chromic Acids, dilute mixed	None Separate	2.2	.016 to .08
Fuller	Zinc	Graphite (Carbon)	Sulphuric Acid (H_2SO_4)	Potassium Dichromate ($K_2Cr_2O_7$)	2.0	0.5 to 0.7
Gaiffe	Zinc	Silver	Zinc Chloride ($ZnCl_2$)	Silver Chloride (AgCl)	1.02	0.5 to 0.6
Maiche	Zinc scraps in bath of Mercury	Platinized Carbon	Common Salt Solution *i. e.* Sodium Chloride (NaCl)	None Separate	1.25	1 to 2
Niaudet	Zinc	Graphite (Carbon)	Common Salt Solution *i. e.* Sodium Chloride (NaCl)	Chloride of Calcium (Lime) ($CaCl_2$)	1.0 to 1.6	5 to 6
Schanschieff	Zinc	Graphite (Carbon)	Mercurial Solution	None Separate	1.56	0.05 to 0.75
Skrivanoff	Zinc	Silver	Caustic Potash or Potassium Hydrate (KOH)	Chloride of Silver (AgCl)	1.5	1.5

Resistances in last column measured in cells standing 6″ × 4″

Table V discloses among other data the resistance of various primary cells. The resistance of a circuit of which a battery forms a part is made up of the external resistance, or the resistance of outside wires and connections, and the internal resistance, or the resistance of the battery itself. The terms *anode* and *kathode* appearing in the second and third columns, are commonly used with reference to electrolysis but may also be applied to primary cells. The current passes from the anode to the kathode through the cell and, therefore, with reference to the cell itself, the anode may be considered the positive element and the kathode the negative element. In regard to the outside circuit, however, the current passes, of course, from the kathode to the anode, and hence with reference to the outside circuit the kathode is positive and the anode negative; ordinarily, the external circuit is considered. As the anode of almost all primary cells is zinc it may readily be remembered that the current passes from the other element *to* the zinc through the *external* circuit.

APPLICATIONS OF OHM'S LAW

Ohm's law is one of the most important and most used laws of electricity.

Current is directly proportional to the electromotive force and inversely proportional to the resistance.

That is, if the electromotive force applied to a circuit is increased, the current will be increased in the same proportion, and if the resistance of a circuit is increased, then the current will be decreased proportionally. Likewise a decrease in the electromotive force causes a proportional decrease in current, and a decrease in resistance causes a proportional increase in current. The current depends only upon the electromotive force and resistance and in the manner expressed by the above simple law. The law may be expressed algebraically as follows

$$current \propto \frac{electromotive\ force}{resistance}$$

The units of these quantities, the ampere, volt, and ohm, have been so chosen that an electromotive force of 1 volt applied to a resistance of 1 ohm, causes 1 ampere of current to flow. Ohm's law may, therefore, be expressed by the equation

$$C = \frac{E}{R}$$

where C is the current in amperes, E the electromotive force in volts, and R the resistance in ohms.

It is, therefore, evident that if the electromotive force and resistance are known the current may be found, or if any two of the three quantities are known the third may be found. If the current and resistance are known the electromotive force may be found from the formula

$$E = R\,C$$

and if the current and electromotive force are known, the resistance may be found from the formula

$$R = \frac{E}{C}$$

Simple Applications. The following examples are given to illustrate the simplest applications of Ohm's law:

EXAMPLE. If the e. m. f. applied to a circuit is 4 volts and its resistance is 2 ohms, what current will flow?

Solution. By the formula for current

$$C = \frac{E}{R} = \frac{4}{2} = 2 \text{ amperes}$$

Ans. 2 amperes.

EXAMPLE. What voltage is necessary to cause a current of 23 amperes to flow through a resistance of 820 ohms?

Solution. By the formula for e. m. f.,

$$E = RC = 820 \times 23 = 18{,}860 \text{ volts.}$$

Ans. 18,360 volts.

EXAMPLE. The e. m. f. applied to a circuit is 110 volts, and it is desired to obtain a current of .6 ampere. What should be the resistance of the circuit?

Solution. By the formula for resistance

$$R = \frac{E}{C} = \frac{110}{.6} = 183.+ \text{ ohms.}$$

Ans. 183+ ohms.

Series Circuits. A circuit made up of several parts all joined in series with each other, is called a series circuit and the resistance of the entire circuit is, of course, the sum of the separate resistances. In calculating the current in such a circuit the total resistance must first be obtained, and the current may then be found by dividing the applied or total e. m. f. by the total resistance. This is expressed by the formula

$$C = \frac{E}{R_1 + R_2 + R_3 + \text{etc.}}$$

EXAMPLE. Three resistance coils are connected in series with each other and have a resistance of 8, 4 and 17 ohms respectively. What current will flow if the e. m. f. of the circuit is 54 volts?

Solution. By the preceding formula

$$C = \frac{E}{R_1 + R_2 + R_3} = \frac{54}{8 + 4 + 17} = \frac{54}{29} = 1.8+ \text{ amperes}$$

Ans. 1.8+ amperes.

EXAMPLE. Six arc lamps, each having a resistance of 5 ohms, are connected in series with each other and the resistance of the connecting wires and other apparatus is 3.7 ohms. What must be the pressure of the circuit to give a desired current of 9.6 amperes?

Solution. The total resistance of the circuit is $R = (6 \times 5) + 3.7 = 33.7$ ohms and the current is to be $C = 9.6$ amperes. Hence, by the formula for e. m. f.,

$$E = R\,C = 33.7 \times 9.6 = 323.+ \text{ volts.}$$

Ans. 323+ volts.

Example. The current passing in a certain circuit was 12 amperes and the e. m. f. was 743 volts. The circuit was made up of 4 sections all connected in series, and the resistance of three sections was 16, 9, and 26 ohms, respectively. What was the resistance of the fourth section?

Solution. Let x = the resistance of the fourth section, then $R = 16 + 9 + 26 + x = 51 + x, C = 12$, and $E = 743$. By the formula for resistance

$$R = \frac{E}{C} \text{ or, } 51 + x = \frac{743}{12} = 61.9 \text{ ohms (approx.)}$$

If $51 + x = 61.9$ we have, by transposing 51 to the other side of the equation

$$x = 61.9 - 51 = 10.9 \text{ ohms}$$

Ans. 10.9 ohms.

Example. A current of 54 amperes flowed through a circuit when the e. m. f. was 220 volts. What resistance should be added in series with the circuit to reduce the current to 19 amperes?

Solution. The resistance in the first case was

$$R = \frac{220}{54} = 4.07 \text{ ohms (approx.)}$$

The resistance in the second must be

$$R = \frac{220}{19} = 11.58 \text{ ohms (approx.)}$$

The required resistance to insert in the circuit is the difference of these two resistances, or $11.58 - 4.07 = 7.51$ ohms.

Ans. 7.51 ohms.

Fall of Potential in a Circuit. Fig. 28 illustrates a series circuit in which the resistances A, B, C, D, and E are connected in series

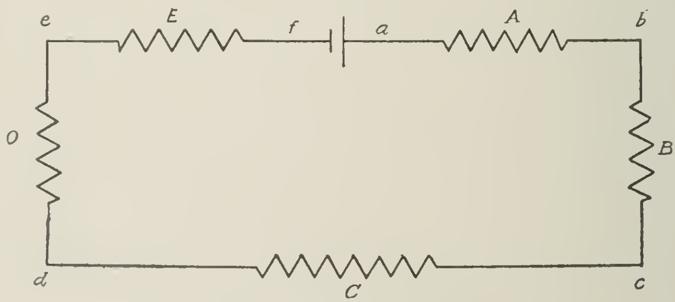


Fig. 28. Battery Circuit Through Resistances in Series

with each other and with the source of electricity. If the e. m. f. is known, the current may be found by dividing the e. m. f. by the sum of all the resistances. Ohm's law may, however, be applied to any

SHE LEARNS THE LESSON OF PATIENCE AND INDUSTRY
Scene from Photoplay, "Her Humble Ministry"
Courtesy of *Lubin Manufacturing Company, Philadelphia*

SCENE FROM PHOTOPLAY, "THE CHILD AND THE TRAMP"
Courtesy of *Thomas A. Edison, Inc., Orange, N. J*

part of a circuit separately, as well as to the complete circuit. Suppose the resistances of A, B, C, D, and E are 4, 3, 6, 3, and 4 ohms, respectively, and assume that the source has no resistance. Suppose the current flowing to be 12 amperes. The e. m. f. necessary to force a current of 12 amperes through the resistance A of 4 ohms is, by applying Ohm's law, equal to $E = R\,C = 4 \times 12 = 48$ volts. Hence, between the points a and b outside of the resistance A, there must be a difference of potential of 48 volts to force the current through this resistance. Also to force the same current through B, the voltage necessary is $3 \times 12 = 36$. Similarly, for each part C, D, and E, there are required 72, 36, and 48 volts, respectively.

As 48 volts are necessary for part A and 36 volts for part B, it is evident that to force the current through both parts a difference of potential of $48 + 36 = 84$ volts is required; that is, the voltage between the points a and c must be 84 volts. For the three parts A, B, and C, $48 + 36 + 72 = 156$ volts are necessary, and for the entire circuit, 240 volts must be applied to give the current of 12 amperes. From the above it is evident that there is a gradual fall of potential throughout the circuit, and if the voltage between any two points of the circuit be measured, the e. m. f. obtained would depend upon the resistance included between these two points. For example, the voltage between points b and d would be found to be $72 + 36 = 108$ volts, or between d and e, 36 volts, etc. From the preceding it is apparent that the fall of potential in a part of a circuit is equal to the current multiplied by the resistance of that part.

This gradual fall of potential, or *drop* as it is commonly called, throughout a circuit, enters into the calculations for the size of conductors or mains supplying current to distant points. The resistances of the conductors cause a certain drop in transmitting the current, depending upon their size and length, and it is, therefore, necessary that the voltage of machines at the supply station shall be great enough to give the voltage necessary at the receiving stations as well as the additional voltage lost in the conducting mains.

For example, in Fig. 28 the voltage necessary between the points e and b is 144 volts, but to give this voltage the source must supply in addition the voltage lost in parts A and E, which equals 96 volts.

Example. The voltage required by 17 arc lamps connected in series is 782 volts and the current is 6.6 amperes. The resistance of the connecting wires is 7 ohms. What must be the e. m. f. applied to the circuit?

Solution. The drop in the connecting wires is $E = R\,C = 7 \times 6.6 = 46.2$ volts. The e.m.f. necessary is, therefore, $782 + 46.2 = 828.2$ volts.

Ans. 828.2+ volts.

Example. The source of e. m. f. supplies 114 volts to a circuit made up of incandescent lamps and conducting wires. The lamps require a voltage of 110 at their terminals, and take a current of 12 amperes. What should be the resistance of the conducting wires in order that the lamps will receive the necessary voltage?

Solution. The allowable drop in the conducting wires is $114 - 110 = 4$ volts. The current to pass through the wires is 12 amperes. Hence, the resistance must be

$$R = \frac{E}{C} = \frac{4}{12} = .33+ \text{ ohms}$$

Ans. .33 ohms.

Divided Circuits. When a circuit divides into two or more parts, it is called a *divided* circuit and each part will transmit a portion of the current.

Such a circuit is illustrated in Fig. 29, the two branches being represented by *b* and *c*. The current passes from the positive pole of the battery through *a* and then divides; part of the current passing

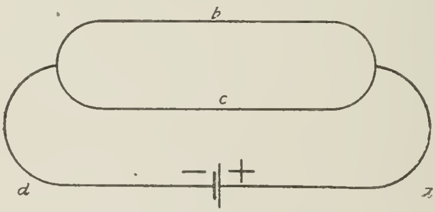


Fig. 29. Divided Circuits

through *b* and part through *c*. The current then unites and passes through *d* to the negative pole of the battery. The part *c* may be considered as the main part of the circuit and *b* as a by-pass about it. A branch which serves as a by-pass to another circuit is called a *shunt* circuit, and the two branches are said to be connected in *parallel.*

In considering the passage of a current through a circuit of this sort, it may be necessary to determine how much current will pass through one branch and how much through the other. Evidently this will depend upon the relative resistance of the two branches, and more current will pass through the branch offering the lesser resistance than through the branch having the higher resistance. If the two parts have equal resistances, then one-half of the total current will pass through each branch. If one branch has twice the resistance of the other, then only one-half as much of the total current will pass through that branch as through the other; that is, one-third of the total current will pass through the first branch and the remaining two-thirds will pass through the second.

The relative strength of current in the two branches will be inversely proportional to their resistances, or directly proportional to their conductances.

Suppose the resistance of one branch of a divided circuit is r_1, Fig. 30, and that of the other is r_2. Then by the preceding law

$$\text{current in } r_1 : \text{current in } r_2 : : r_2 : r_1$$

Also,

$$\text{current in } r_1 : \text{total current} : : r_2 : r_1 + r_2$$

and

$$\text{current in } r_2 : \text{total current} : : r_1 : r_1 + r_2$$

Let C represent the total current, i_1 the current through the resistance r_1 and i_2 the current through the resistance r_2. Then the

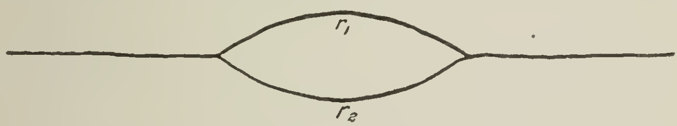


Fig. 30. Joint Resistance of a Divided Circuit

two preceding proportions are expressed by the following formulas

$$i_1 = \frac{Cr_2}{r_1 + r_2} \quad \text{and } i_2 = \frac{Cr_1}{r_1 + r_2}$$

EXAMPLE. The total current passing in a circuit is 24 amperes. The circuit divides into two branches having resistances of 5 and 7 ohms, respectively. What is the current in each branch?

Solution. In this case $C = 24$, $r_1 = 5$, and $r_2 = 7$. Substituting these values in the above formulas, we have

$$i_1 = \frac{Ir_2}{r_1 + r_2} = \frac{24 \times 7}{5 + 7} = 14 \text{ amperes}$$

and

$$i_2 = \frac{Ir_1}{r_1 + r_2} = \frac{24 \times 5}{7 + 7} = 10 \text{ amperes}$$

Ans. { In 5 ohm branch, 14 amperes. In 7 ohm branch, 10 amperes.

Joint Resistance of Divided Circuits. As a divided circuit offers two paths to the current, it follows that the joint resistance of the two branches will be less than the resistance of either branch alone. The ability of a circuit to conduct electricity is represented by its conductance, which is the reciprocal of resistance; and the conductance of a divided circuit is equal to the sum of the conductances of its parts.

For example, in Fig. 30, the conductance of the upper branch equals $\frac{1}{r_1}$ and that of the lower branch equals $\frac{1}{r_2}$. If R represents the joint resistance of the two parts then the joint conductance equals

$$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} = \frac{r_1 + r_2}{r_1 r_2}$$

Having thus obtained the joint conductance, the joint resistance is found by taking the reciprocal of the conductance, that is,

$$R = \frac{r_1 r_2}{r_1 + r_2}$$

This formula may be stated as follows:

The joint resistance of a divided circuit is equal to the product of the two separate resistances divided by their sum.

For example, suppose the resistance of each branch to be 2 ohms. The conductance of the circuit will be,

$$\frac{1}{R} = \frac{1}{2} + \frac{1}{2} = 1, \text{ and hence } R = 1 \text{ ohm}$$

Also by the preceding formula

$$R = \frac{2 \times 2}{2 + 2} = 1 \text{ ohm}$$

The resistance of a divided circuit in which each branch has a resistance of 2 ohms is, therefore, 1 ohm.

EXAMPLE. The resistances of two separate conductors are 3 and 7 ohms, respectively. What would be their joint resistance if connected in parallel?

Solution. In this case $r_1 = 3$ and $r_2 = 7$, hence, by the formula

$$R = \frac{3 \times 7}{3 + 7} = 2.1 \text{ ohms.}$$

Ans. 2.1 ohms.

Suppose, as illustrated in Fig. 31, the conductors having resistances equal to r_1, r_2, and r_3, respectively, are connected in parallel. The joint total conductance will then be equal to

$$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} = \frac{r_2 r_3 + r_1 r_3 + r_1 r_2}{r_1 r_2 r_3}$$

and as the joint resistance is the reciprocal of the joint conductance, the joint resistance R of the three branches is expressed by the formula

$$R = \frac{r_1 r_2 r_3}{r_2 r_3 + r_1 r_3 + r_1 r_2}$$

EXAMPLE. What is the joint resistance when connected in parallel, of three wires whose respective resistances are 41, 52, and 29 ohms, respectively?

Solution. In this case $r_1 = 41$, $r_2 = 52$, and $r_3 = 29$.
Hence, by the preceding formula,

$$R = \frac{41 \times 52 \times 29}{52 \times 29 + 41 \times 29 + 41 \times 52} = 12.8+ \text{ ohms.}$$

Ans. 12.8+ ohms.

In general, for any number of conductors connected in parallel, the joint resistance is found by taking the reciprocal of the sum of the reciprocals of the separate resistances.

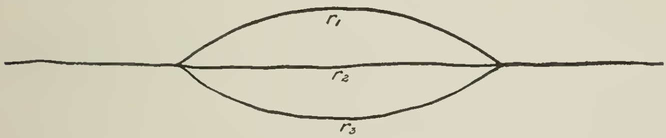


Fig. 31. Triply Divided Circuit

EXAMPLE. A circuit is made up of five wires connected in parallel, and their separate resistances are respectively 12, 21, 28, 8, and 42 ohms. What is the joint resistance?

Solution. The sum of the conductances is

$$\frac{1}{12} + \frac{1}{21} + \frac{1}{28} + \frac{1}{8} + \frac{1}{42} = \frac{53}{168}$$

Hence the joint resistance equals

$$R = \frac{168}{53} = 3.1 + \text{ ohms}$$

Ans. 3.1 + ohms.

If the resistance of each branch is known and also the potential difference between the points of union, then the current in each branch may be found by applying Ohm's law to each branch separately. For example, if this potential difference were 96 volts, and the separate resistances of the 4 branches were 8, 24, 3, and 48 ohms, respectively, then the current in the respective branches would be 12, 4, 32, and 2 amperes, respectively.

If the current in each branch is known, and also the potential difference between the points of union, then the resistance of each branch may likewise be found from Ohm's law.

The following examples are given to illustrate the application of the preceding principles.

EXAMPLES FOR PRACTICE

1. Two conductors having resistances of 71 and 19 ohms, respectively, are connected in parallel, and the total current passing in the circuit is 37 amperes. What current passes in the conductor whose resistance is 71 ohms? Ans. 7.8+ amperes.

2. What is the joint resistance of two wires connected in parallel if their separate resistances are 2 and 8 ohms, respectively? Ans. 1.6 ohms.

3. What is the joint resistance of three wires when connected in parallel, whose separate resistances are 5, 7, and 9 ohms, respectively? Ans. 2.2+ ohms.

4. Three wires, the respective resistances of which are 8, 10, and 20 ohms, are joined in parallel. What is their joint resistance? Ans. 3.6+ ohms.

5. Four wires are joined in parallel, and their separate resistances are 2, 4, 6, and 9 ohms, respectively. What is the joint resistance of the conductor thus formed? Ans. .97+ ohms.

WIRING METHODS

PLANNING AN INSTALLATION

The first step in planning a wiring installation, is to gather all tne data which will affect either directly or indirectly the system of wiring and the manner in which the conductors are to be installed. The data will include: Kind of building; construction of building; space available for conductors; source and system of electric-current supply; and all details which will determine the method of wiring to be employed. These last items materially affect the cost of the work, and are usually determined by the character of the building and by commercial considerations.

Method of Wiring. In a modern fireproof building, the only system of wiring to be recommended is that in which the conductors are installed in rigid conduits; although, even in such cases, it may be desirable, and economy may be effected thereby, to install the larger feeder and main conductors exposed on insulators using weather-proof slow-burning wire. This latter method should be used, however, only where there is a convenient runway for the conductors, so that they will not be crowded and will not cross pipes, ducts, etc., and also will not have too many bends. Also, the local inspection authorities should be consulted before using this method.

For mills, factories, etc., wires exposed on cleats or insulators are usually to be recommended, although rigid conduit, flexible conduit, or armored cable may be desirable.

In finished buildings, and for extensions of existing outlets, where the wiring could not readily or conveniently be concealed, moulding is generally used, particularly where cleat wiring or other exposed methods of wiring would be objectionable. However, as has already been said, moulding should not be employed where there is any liability to dampness.

In finished buildings, particularly where they are of frame construction, flexible steel conduits or armored cable are to be recommended.

While in new buildings of frame construction, knob and tube wiring is frequently employed, this method should be used only where the question of first cost is of prime importance. While armored cable will cost approximately 50 to 100 per cent more than knob and tube wiring, the former method is so much more permanent and is so much safer that it is strongly recommended.

Systems of Wiring. The system of wiring—that is, whether the two-wire or the three-wire system shall be used—is usually determined by the source of supply. If the source of supply is an isolated plant, with simple two-wire generators, and with little possibility of current being taken from the outside at some future time, the wiring in the building should be laid out on the two-wire system. If, on the other hand, the isolated plant is three-wire (having three-wire generators, or two-wire generators with balancer sets), or if the current is taken from an outside source, the wiring in the building should be laid out on a three-wire system.

It very seldom happens that current supply from a central station is arranged with other than the three-wire system inside of buildings, because, if the outside supply is alternating current, the transformers are usually adapted for a three-wire system. For small buildings, on the other hand, where there are only a few lights and where there would be only one feeder, the two-wire system is used. As a rule, however, when the current is taken from an outside source, it is best to consult the engineer of the central station supplying the current, and to conform with his wishes. As a matter of fact, this should be done in any event, in order to ascertain the proper voltage for the lamps and for the motors, and also to ascertain whether the central station will supply transformers, meters, and lamps, for, if these are not thus supplied, they should be included in the contract for the wiring.

Location of Outlets. A set of plans, including elevation and details, if any, and showing decorative treatment of the various rooms, should be obtained from the architect. A careful study should then be made by the architect, the owner, and the engineer, or some other person qualified to make recommendations as to illumination. The location of the outlets will depend: *First*, upon the decorative treatment of the room, which determines the æsthetic and architectural effects; *second*, upon the type and general form of fixtures to be used, which should be previously decided on; *third*, upon the tastes of the owners or occupants in regard to illumination in general, as it is found that tastes vary widely in regard to amount and kind of illumination.

The location of the outlets, and the number of lights required at each, having been determined, the outlets should be marked on the plans.

The architect should then be consulted as to the location of the centers of distribution, the available points for the risers or feeders, and the available space for the branch circuit conductors.

In regard to the *rising points for the feeders and mains*, the following precautions should be used in selecting chases:

The space should be amply large to accommodate all the feeders and mains likely to rise at that given point. This seems trite and unnecessary but it is the most usual trouble with chases for risers. Formerly architects and builders paid little attention to the requirements for chases for electrical work; but in these later days of 2-inch and 2½-inch conduit, they realize that these pipes are not so invisible and mysterious as the force they serve to distribute, particularly when twenty or more such conduits must be stowed away in a building where no special provision has been made for them.

If possible, the space should be devoted solely to electric wiring. Steam pipes are objectionable on account of their temperature; and these and all other pipes are objectionable in the same space occupied by the electrical conduits, for if the space proves too small, the electric conduits are the first to be crowded out.

The chase, if possible, should be continuous from the cellar to the roof, or as far as needed. This is necessary in order to avoid unnecessary bends or elbows, which are objectionable for many reasons.

In similar manner, the location of *cut-out cabinets or distributing centers* should fulfill the following requirements:

They should be accessible at all times.

They should be placed sufficiently close together to prevent the circuits from being too long.

They should not be placed in too prominent a position, as that is objectionable from the architect's point of view.

They should be placed as near as possible to the rising chases, in order to shorten the feeders and mains supplying them.

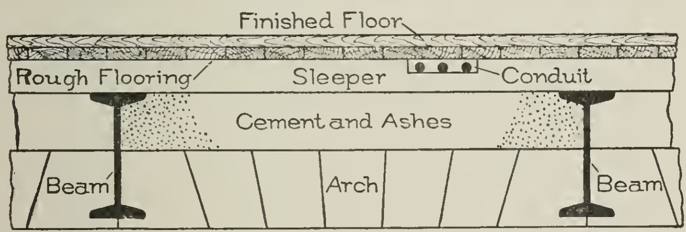


Fig. 32. Running Conductors Concealed Under Floor in Fireproof Building

Having determined the system and method of wiring, the location of outlets and distributing centers, the next step is to lay out the *branch circuits* supplying the various outlets.

Before starting to lay out the branch circuits, a drawing showing the floor construction, and showing the space between the top of the beams and girders and the flooring, should be obtained from the architect. In fireproof buildings of iron or steel construction, it is almost the invariable practice, where the work is to be concealed, to run the conduits over the beams, under the rough flooring, carrying them between the sleepers when running parallel to the sleepers, and notching the latter when the conduits run across them, Fig. 32. In wooden frame buildings, the conduits run parallel to the beams and to the furring, Fig. 33; they are also sometimes run below the beams. In the latter case the beams have to be notched, and this is allowable only in certain places, usually near the points where the beams are supported. The architect's drawing is, therefore, necessary in order that the location and course of the conduits may be indicated on the plans.

The first consideration in laying out the branch circuit is the *number of outlets* and *number of lights* to be wired on any one branch circuit. The *Rules of the National Electric Code* require that "no set of incandescent lamps requiring more than 660 watts, whether grouped on one fixture or on several fixtures or pendents, will be dependent on one cut-out." While it would be possible to have branch circuits supplying more than 660 watts, by placing various cut-outs at different points along the route of the branch circuit, so as to subdivide it into small sections to comply with the rule, this method is not recommended, except in certain cases, for exposed wiring in factories or mills. As a rule, the proper method is to have the cut-outs located at the center

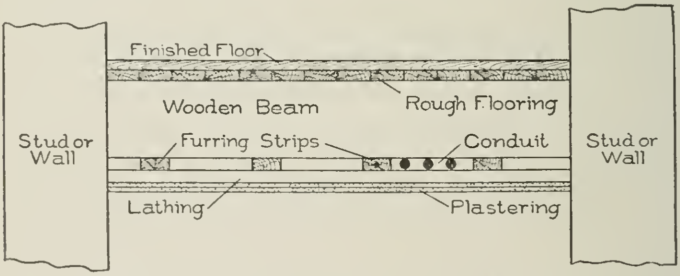


Fig. 33. Running Conductors Concealed Under Floor in Wooden Frame Building

of distribution, and to limit each branch circuit to 660 watts, which corresponds to twelve or thirteen 50-watt lamps, twelve being the usual limit. Attention is called to the fact that the inspectors usually allow 50 watts for each socket connected to a branch circuit; and although 8-candle-power lamps may be placed at some of the outlets, the inspectors hold that the standard lamp is approximately 50 watts, and for that reason there is always the likelihood of a lamp of that capacity being used, and their inspection is based on that assumption. Therefore, to comply with the requirements, an allowance of not more than twelve lamps per branch circuit should be made.

In ordinary practice, however, it is best to reduce this number still further, so as to make allowance for future extensions or to increase the number of lamps that may be placed at any outlet. For this reason, it is wise to keep the number of the outlets on a circuit at the lowest point consistent with economical wiring. It has been proven by actual practice, that the best results are obtained by limiting the number to five or six outlets on a branch circuit. Of course, where all the outlets have a single light each, it is frequently necessary, for reasons of economy, to increase this number to eight, ten, and, in some cases, twelve outlets.

Now, as to the course of the circuit work, little need be said, as it is largely influenced by the relative position of the outlets, cut-outs, switches, etc. Between the cut-out box and the first outlet, and between the outlets, it will have to be decided, however, whether the circuits shall run at right angles to the walls of the building or room, or whether they shall run direct from one point to another, irrespective of the angle they make to the sleepers or beams. Of course, in the latter case, the advantages are that the cost is somewhat less and the number of elbows and bends is reduced. If the tubes are bent, however, instead of using elbows, the difference in cost is usually very slight, and probably does not compensate for the disadvantages that would result from running the tubes diagonally. As to the number of bends, if branch circuit work is properly laid out and installed, and a proper size of tube used, it rarely happens that there is any difference in "pulling" the branch circuit wires. It may happen, in the event of a very long run or one having a large number of bends, that it might be advisable to adopt a short and more direct route.

Up to this time, the location of the distribution centers has been made solely with reference to architectural considerations; but they must now be considered in conjunction with the branch circuit work.

It frequently happens that, after running the branch circuits on the plans, we find, in certain cases, that the position of centers of distribution may be changed to advantage, or sometimes certain groups may be dispensed with entirely and the circuits run to other points. We now see the wisdom of ascertaining from the architect where cut-out groups may be located, rather than selecting particular points for their location.

As a rule, wherever possible, it is wise to limit the length of each branch circuit to 100 feet; and the number and location of the distributing centers should be determined accordingly.

It may be found that it is sometimes necessary and even desirable to increase the limit of length. One instance of this may be found in hall or corridor lights in large buildings. It is generally desirable, in such cases, to control the hall lights from one point; and, as the number of lights at each outlet is generally small, it would not be economical to run mains for sub-centers of distribution. Hence, in instances of this character, the length of runs will frequently exceed the limit named. In the great majority of cases, however, the best results are obtained by limiting the runs to 90 or 100 feet.

There are several good reasons for placing such a limit on the length of a branch circuit. To begin with, assuming that we are going to place a limit on the loss in voltage (drop) from the switchboard to the lamp, it may easily be proven that up to a certain reasonable limit it is more economical to have a larger number of distributing centers and shorter branch circuits, than to have fewer centers and longer circuits. It is usual, in the better class of work, to limit the loss in voltage in any branch circuit to approximately one volt. Assuming this limit (one volt loss), it can readily be calculated that the number of lights at one outlet which may be connected on a branch circuit 100 feet long (using No. 14 B. & S. wire), is *four;* or in the case of outlets having a single light each, *five* outlets may be connected on the circuit, the first being 60 feet from the cut-out, the others being 10 feet apart.

These examples are selected simply to show that, if the branch circuits are much longer than 100 feet, the loss must be increased to more than one volt, or else the number of lights that may be connected to one circuit must be reduced to a very small quantity, provided, of course, the size of the wire remains the same.

Either of these alternatives is objectionable—the first, on the score of regulation; and the second, from an economical standpoint. If, for instance, the loss in a branch circuit with all the lights turned on is four volts (assuming an extreme case), the voltage at which a lamp on that circuit burns will vary from four volts, depending on the number of lights burning at a time. This, of course, will cause the lamp to burn below candle-power when all the lamps are turned on, or else to diminish its life by burning above the proper voltage when it is the only lamp burning on the circuit. Then, too, if the drop in the branch circuits is increased, the sizes of the feeders and the mains must be correspondingly increased (if the total loss remains the same), thereby increasing their cost.

If the number of lights on the circuit is decreased, we do not use to good advantage the available carrying capacity of the wire.

Of course, one solution of the problem would be to increase the size of the wire for the branch circuits, thus reducing the drop. This, however, would not be desirable, except in certain cases where there were a few long circuits, such as for corridor lights or other special control circuits. In such instances as these, it would be better to increase the sizes of the branch circuit to No. 12 or even No. 10 B. &. S. gauge conductors, than to increase the numbers of centers of distribution for the sake of a few circuits only, in order to reduce the number of lamps (or loss) within the limit.

The method of calculating the loss in conductors has been given elsewhere; but it must be borne in mind, in calculating the loss of a branch circuit supplying more than one outlet, that separate calculations must be made for each portion of the circuit. That is, a calculation must be made for the loss to the first outlet, the length in this case being the distance from the center of distribution to the first outlet, and the load being the total number of lamps supplied by the circuit. The next step would be to obtain the loss between the first and second outlet, the length being the distance between the two outlets, and the load, in this case, being the total number of lamps supplied by the circuit, *minus* the number supplied by the first outlet; and so on. The loss for the total circuit would be the sum of these losses for the various portions of the circuits.

Feeders and Mains. If the building is more than one story, an elevation should be made showing the height and number of stories. On this elevation, the various distributing centers should be shown diagrammatically; and the current in amperes supplied through each center of distribution, should be indicated at each center. The next step is to lay out a tentative system of feeders and mains, and to ascertain the load in amperes supplied by each feeder and main. The estimated length of each feeder and main should then be determined, and calculation made for the loss from the switchboard to each center of distribution. It may be found that in some cases it will be necessary to change the arrangement of feeders or mains, or even the centers of distribution, in order to keep the total loss from the switchboard to the lamps within the limits previously determined. As a matter of fact, in important work, it is always best to lay out the entire work tentatively in a more or less crude fashion, according to the "cut-and-dried" method, in order to obtain the best results, because the entire layout may be modified after the first preliminary layout has been made. Of course, as one becomes more experienced and skilled in these matters, the final layout is often almost identical with the first preliminary arrangement.

WIRING AN OFFICE BUILDING

The building selected as a typical sample of a wiring installation is that of an office building located in Washington, D. C. The figures shown are reproductions of the plans actually used in installing the work.

The building consists of a basement and ten stories. It is of fireproof construction, having steel beams with terra-cotta flat arches. The main walls are of brick and the partition walls of terra-cotta blocks, finished with plaster. There is a space of approximately five inches between the top of the iron beams and the top of the finished floor, of which space about 3 inches was available for running the electric conduits. The flooring is of wood in the offices, but of concrete, mosaic, or tile in the basement, halls, toilet-rooms, etc.

The electric current supply is derived from the mains of the local illuminating company, the mains being brought into the front of the building and extending to a switchboard located near the center of the basement.

As the building is a very substantial fireproof structure, the only method of wiring considered was that in which the circuits would be installed in iron conduits.

Electric Current Supply. The electric current supply is direct current, two-wire for power, and three-wire for lighting, having a potential of 236 volts between the outside conductors, and 118 volts between the neutral and either outside conductor.

Switchboard. On the switchboard in the basement are mounted wattmeters, provided by the local electric company, and the various switches required for the control and operation of the lighting and power feeders. There is a total of ten triple-pole switches for lighting, and eighteen for power. An indicating voltmeter and ampere meter are also placed in the switchboard. A voltmeter is provided with a double-throw switch, and so arranged as to measure the potential across the two outside conductors, or between the neutral conductor and either of the outside conductors. The ampere meter is arranged with two shunts, one being placed in each outside leg; the shunts are connected with a double-pole, double-throw switch, so that the ampere meter can be connected to either shunt and thus measure the current supplied on each side of the system.

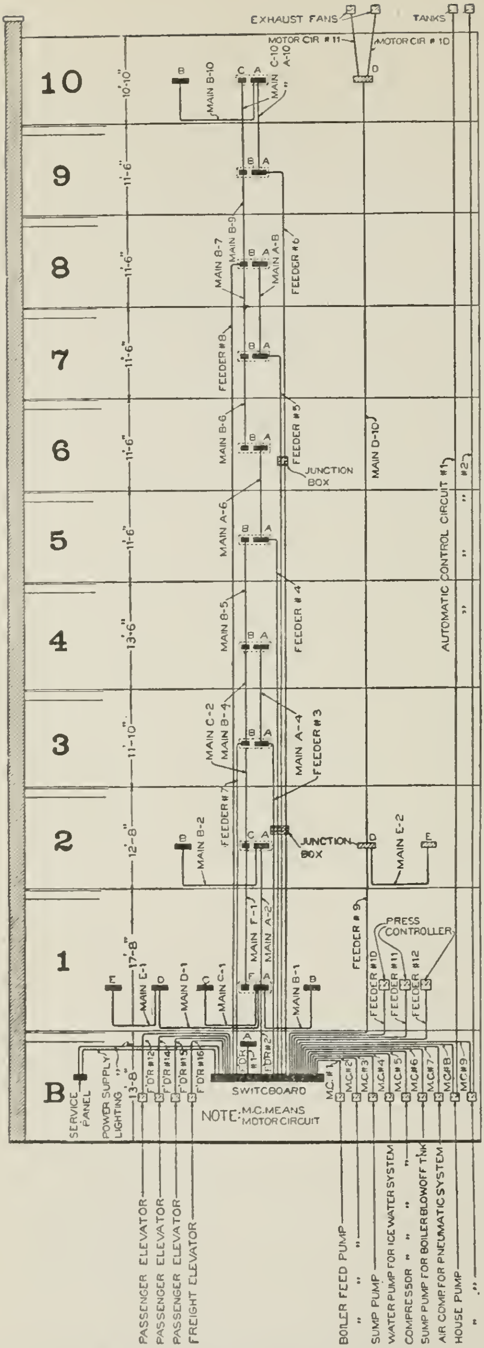
Character of Load. The building is occupied partly as a newspaper office, and there are several large presses in addition to the usual linotype machines, trimmers, shavers, cutters, saws, etc. There are also electrically-driven exhaust fans, house pumps, air-compressors, etc. The upper portion of the building is almost entirely devoted to offices rented to outside parties. The total number of motors supplied was 55; and the total number of outlets, 1,100, supplying 2,400 incandescent lamps and 4 arc lamps.

Feeders and Mains. The arrangement of the various feeders and mains, the cut-out centers, mains, etc., which they supply, are shown diagrammatically in Fig. 34, which also gives in schedule the sizes of feeders, mains, and motor circuits, and the data relating to the cut-out panels.

Although the current supply was to be taken from an outside source, yet, inasmuch as there was a probability of a plant being installed in the building itself at some future time, the three-wire system of feeders and mains was designed, with a neutral conductor equal to the combined capacity of the two outside conductors, so that 120-volt two-wire generators could be utilized without any change in the feeders.

Basement. The plan of the basement, Fig. 35, shows the branch circuit wiring for the outlets in the basement, and the location of the main switchboard. It also shows the trunk cables for the interconnection system serving to provide the necessary wires for telephones, tickers, messenger calls, etc., in all the rooms throughout the building, as will be described later.

To avoid confusion, the feeders were not shown on the basement



FEEDERS

No.	End at: Floor	End at: Cut-out	Branch Cir	Lights	Lenght-Ft (One Way)	Loss in Volts	Size of Wire: No. Middle Cond'r	Size of Wire: No. Outside Cond'r	Inside Dia. of Conduit Allowed *
1	BASMT	A	18	115	48	0.84	2	4	1.25"
2	1 ST	"	83	533	88	1.18	400000	4-0	2.5"
3	3 RD	"	43	258	119	1.68	4-0	0	2"
4	5 TH	"	44	296	147	1.78	250000	2-0	2.5"
5	7 TH	"	"	292	173	1.72	300000	3-0	"
6	9 TH	"	124	365	200	1.61	450000	250000	3"
7	3 RD	B	26	131	119	1.5	0	3	1.5"
8	8 TH	"	27	128	185	1.8	2-0	2	2"
L-S	SW.B	"		2165	138	1.5	4000000	2000000	***
9	2 ND	D			148		400000		3"
10	PRESS				83		700000		**
11	"				118		"		"
12	"				"		"		"
13	PASS.ELV				58		4-0		2"
14	"				"		"		"
15	"				"		"		"
16	FRGT ELV				148		"		"
P-S	SW B				138		2000000		****

* ALL CONDUCTORS IN ONE CONDUIT.
** SEPARATE CONDUIT FOR EACH CONDUCTOR
*** THIS FEEDER IS TO BE DIVIDED INTO FOUR (4)
" CONDUCTORS OF # 2000000 C.M. EACH.
" EACH CONDUCTOR IS TO BE INSTALLED IN A SEP-
" ARATE 3" (INSIDE DIAM.) CONDUIT
L.S.=LIGHTING SUPPLY
P.S.=POWER "
**** SEPARATE 3" (INSIDE DIAM.) CONDUIT FOR EACH
" CONDUCTOR

MAINS

Mains	Supplied by: Feeder #	Supplied by: Cut Out	Supplied by: Floor	Lights	Length-Ft (One Way)	Loss in Volts	Size of Wire: No. Middle Cond'r	Size of Wire: No. Outside Cond'r	Inside Dia. of Conduit Allowed *
A-2	2	A	1 ST	284	63	0.72	250000	2-0	2.5"
A-4	3	"	3 RD	147	18	0.41	2	4	1.25"
A-6	4	"	5 TH	146	"	0.4	"	"	"
A-8	5	"	7 TH	"	"	"	"	"	"
A-10	6	"	9 TH	171	"	0.29	0	3	1.5"
B-1	2	"	1 ST	76	70	0.51	"	"	"
B-2	"	"	"	206	58	0.58	4-0	0	2"
B-10	6	"	10 TH	87	44	0.37	0	3	1.5"
D-1	2	"	1 ST	120	12	0.22	2	4	1.25"
C-1	"	"	"	70	44	0.30	0	3	1.5"
F-1	7	C	2 ND	22	61	0.41	8	10	1"
C-2	"	B	3 RD	47	18	0.52	"	"	"
B-4	"	"	"	56	"	0.60	"	"	"
B-5	"	"	4 TH	28	"	0.31	"	"	"
B-6	8	"	7 TH	32	"	0.35	"	"	"
B-7	"	"	8 TH	56	"	0.60	"	"	"
B-9	"	"	"	44	"	0.48	"	"	"
C-10	"	"	9 TH	16	"	0.28	10	12	"
E-1	2	A	1 ST	61	92	0.86	2	4	1.25"
E-2	9	D	2 ND		84		0	0	1.5"
D-10	"	"	"		108		2	2	1.25"

* ALL CONDUCTORS IN ONE CONDUIT

MOTOR CIRCUITS

No.	Supplied by: Feeder	Supplied by: Cutout	Supplied by: Floor	H.P. Supplied	Current in Amp.	Length in Feet (One Way)	Size of Wire	Inside Diam. of Conduit Allowed *
1			BSMT	15	60	74	2	1.25"
2			"	"	"	"	"	"
3			"	5	20	50	8	1"
4			"	"	"	40	"	"
5			"	15	60	"	2	1.25"
6			"	3	12	48	10	0.75"
7			"		20	"	8	1"
8			"	15	60	80	2	1.25"
9	MAIN		"	"	"	"	"	"
10	D-10	D	10 TH	7.5	30	134	6	1"
11	"	"	"	"	"	28	"	"

* BOTH CONDUCTORS IN ONE CONDUIT

CUT-OUTS

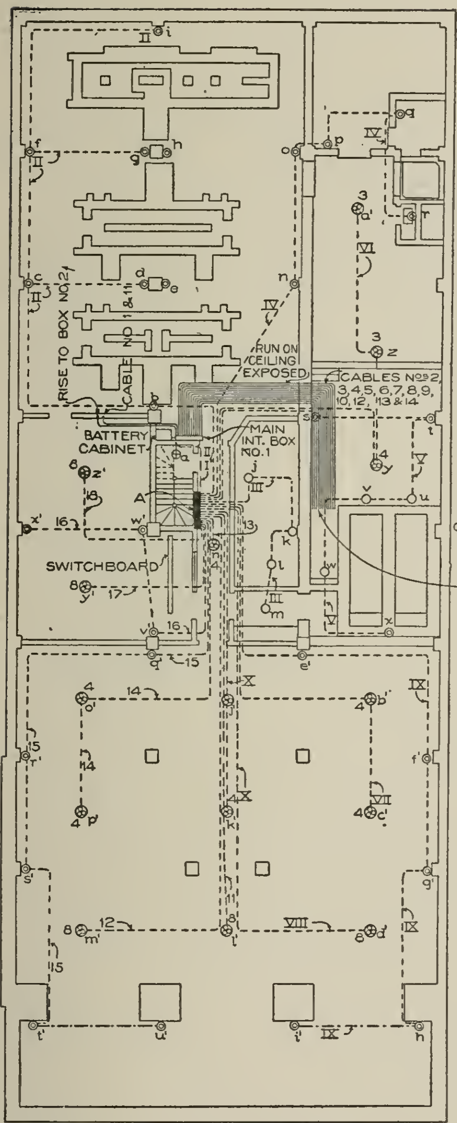
Name	Floor	Mains	Branch Circuits	P.B. Switches	Meters	T.P.S.T. 25 Amp.	T.P.S.T. 50 "	T.P.S.T. 100 "	T.P.S.T. 150 "	T.P.S.T. 200 "	D.P.S.T. 25 "	D.P.S.T. 50 "	D.P.S.T. 100 "	D.P.S.T. 125 "	D.P.S.T. 150 "
A	BSMT		20	10											
"	1 ST	4					2	1		1					
B	"		10	10											
C	"		"	"											
D	"	1	12	8			2								
E	"		"	4											
F	"		8	6											
A	2 ND	1	16	1			1*		1						
B	"		32	3											
C	"	1	4	4		2									
D	"	1									24		1	1	
E	"										4	6			
A	3 RD	1	22	1				2							
B	"	2	4	4		3									
A	4 TH		24	1											
B	"	1	4	4		2									
A	5 TH	1	24	1				2							
B	"		4	4											
A	6 TH		28	1											
B	"		4	4											
A	7 TH	1	24	1				2							
B	"	1	4	4		2									
A	8 TH		24	1											
B	"	2	4	4		3									
A	9 TH	1	24	1				1*	1						
B	"	1	4	4		2									
A	10 TH	1	24	1			1*	1							
B	"		16	1											
C	"		4	4											
D	"										4	2			

* MAIN SWITCH

Fig. 34 Wiring of an Office Building. Diagram Showing Arrangement of Feeders and Mains Cut-Out Centers, etc.

SCENE FROM PHOTOPLAY, "BACK TO THE PRIMITIVE"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

FOLCHETTO DECLARES HIS LOVE
Scene from Pathé film, "Undying Love"
Courtesy of *Pathé Frères, New York and Paris*



SCHEDULE OF CIRCUITS

NO.	SUPPLIED by CUTOUT	SUPPLIED by MAIN	No. of BRANCHES	OUTLETS SUPPLIED	TOTAL OUTLETS	TOTAL LIGHTS	AT WHAT POINT CONTROLLED
I	A	FOR NO 1	1	a	1	1	
II	"	"	3	bcdefghi	8	8	
III	"	"	1	jklm	4	4	
IV	"	"	1	nopqr	5	5	
V	"	"	1	stuvwx	6	6	
VI	"	"	1	yza'	3	10	S at A
VII	"	"	1	b'c'	2	8	" " "
VIII	"	"	1	d'	1	8	" " "
IX	"	"	1	e'f'g'h'i'	5	5	
X	"	"	1	j'k'	2	8	S at A
11	"	"	1	l'	1	8	" " "
12	"	"	1	m'	1	8	" " "
13	"	"	1	n'	1	4	" " "
14	"	"	1	o'p	2	8	" " "
15	"	"	1	q'r's't'u'	5	5	
16	"	"	1	v'w'x	3	3	
17	"	"	1	y'	1	8	S at A
18	"	"	1	z'	1	8	" " "
					52	115	

CABLE NO. 2 RISES TO 2nd FLOOR
" " 3 " " 3rd "
" " 4 " " 4th "
" " 5 " " 5th "
" " 6 " " 6th "
" " 7 " " 7th "
" " 8 " " 8th "
" " 9 " " 9th "
" " 10 " " 10th "
" " 12 " " 2nd "
" " 13 " " 5th "
" " 14 " " 8th "

Key Showing Explanation of Various Symbols used in Figs. 41 to 46 Inclusive

- Ceiling Chandelier
- Wall Bracket
- Gooseneck Bracket
- Wall Socket
- Drop Cord
- Arc Lamp
- Cooper-Hewitt Lamp
- Cluster
- Floor Outlet
- Desk Light
- Extension Outlet
- Push Button Switch
- Snap Switch
- Junction Box
- Electric Clock
- Master Clock
- Motor Starter
- CutOut Panel
- Interconnection Box
- Power Panel
- Pull Box
- Circuit under Floor
- " " above
- " on Ceiling Exposed
- Service Line under Floor

Fig. 35. Wiring an Office Building. Basement Plan Showing Branch Circuit Wiring for Outlets in Basement, Location of Main Switchboard, and Trunk Cables of the Interconnection System Providing Wires for Telephone, Ticker, and Messenger Call Service, etc.

plan, but were described in detail in the specification, and installed in accordance with directions issued at the time of installation. The electric current supply enters the building at the front, and a service switch and cut-out are placed on the front wall. From this point, a two-wire feeder for power and a three-wire feeder for lighting, are run to the main switchboard located near the center of the basement. Owing to the size of the conduits required for these supply feeders, as well as the main feeders extending to the upper floors of the building, the said conduits are run exposed on substantial hangers suspended from the basement to the ceiling.

First Floor. The rear portion of the building from the basement through the first floor, and including the mezzanine floor, between the first and second floors, at the rear portion of the building only, is utilized as a press room for several large and heavy modern newspaper presses. The motors and controllers for these presses are located on the first floor. A separate feeder for each of these press motors is run directly from the main switchboard to the motor controller in each case. Empty conduits were provided, extending from the controllers to the motor in each case, intended for the various control wires installed by the contractor for the press equipments.

One-half of the front portion of the first floor is utilized as a newspaper office; the remaining half, as a bank.

Second Floor. The rear portion of the second floor is occupied as a composing and linotype room, and is illuminated chiefly by means of drop-cords from outlets located over the linotype machines and over the compositors' cases. Separate $\frac{1}{8}$-horse-power motors are provided for each linotype machine, the circuits for the same being run underneath the floor.

Upper Floors. The upper floors are similar in all respects with the exception of certain changes in partitions, which are not material for the purpose of illustration or for practical example. The circuit work is sufficiently intelligible from the plan to require no further explanation.

Interconnection System. In the interconnection system, the main interconnection box is located in the basement; adjoining this main box is located the terminal box of the local telephone company. A separate system of feeders is provided for the ticker system, as these conductors require somewhat heavier installation, and it was thought inadvisable to place them in the same conduits with the telephone wires, owing to the higher potential of ticker circuits. A separate interconnection cable runs to each floor, for telephone and messenger call purposes; and a central box is placed near the rising point at each floor, from which run subsidiary cables to several points symmetrically located on the various floors. From these subsidiary boxes, wires can be run to the various offices requiring telephone or other service. Small pipes are provided to serve as raceways from office to office, so as to avoid cutting partitions. In this way, wires can be quickly provided for any office in the building without damaging the building in any way whatever; and, as provision is made for a special wooden moulding near the ceiling to accommodate these wires, they can be run around the room without disfiguring the walls. All the main cables and subsidiary wires are connected with special interconnection blocks numbered serially; and a schedule is provided in the main interconnection box in the basement, which enables any wire originating thereat, to be readily and conveniently traced though the building. All the main cables and subsidiary cables are run in iron conduits.

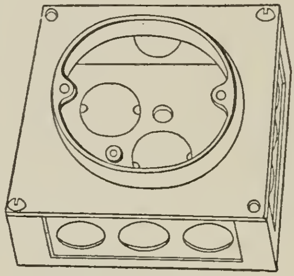


Fig. 36. Universal and Knock Out Type of Outlet Box

OUTLET-BOXES, CUT-OUT PANELS, AND OTHER ACCESSORIES

Outlet Boxes. Before the introduction of iron conduits, outlet-

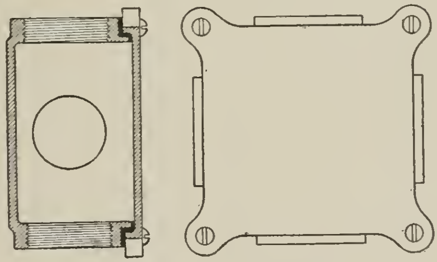


Fig. 37. Water-Tight Outlet Box

boxes were considered unnecessary, and with a few exceptions were not used, the conduits being brought to the outlet and cut off after the walls and ceilings were plastered. With the introduction of iron conduits, however, the necessity for outlet-boxes was realized; and the *Rules of the Fire Underwriters* were modified so as to require their use. The *Rules of the National Electric Code* now require outlet-boxes to be used with rigid iron and flexible steel conduits, and with armored cables. A portion of the rule requiring their use is as follows:

All interior conduits and armored cables must be equipped at every outlet with an approved outlet-box or plate.

Outlet-plates must not be used where it is practicable to install outlet-boxes.

In buildings already constructed, where the conditions are such that neither outlet-box nor plate can be installed, these appliances may be omitted by special permission of the inspection department having jurisdiction, providing the conduit ends are bushed and secured.

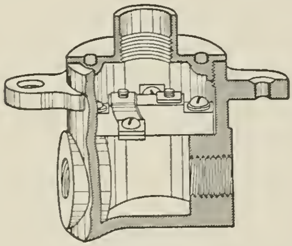


Fig. 38.

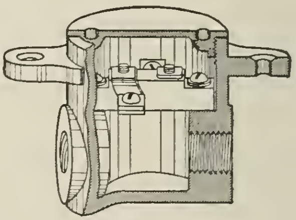


Fig. 39.

Types of Floor Outlet Boxes

Fig. 36 shows a typical form of outlet-box for bracket or ceiling outlets of the *universal type*. When it is desired to make an opening for the conduits, a blow from a hammer will remove any of the weakened portion of the wall of the outlet-box, as may be required. This form of outlet-box is frequently referred to as the *knock-out type*. Other forms of outlet-boxes are made with the openings cast in the box at the required points, this class being usually stronger and better made than the universal type. The advantages of the universal type of outlet-box are that one form of box will serve for any ordinary conditions, the openings being made according to the number of conduits and the directions in which they enter the box.

Fig. 37 shows a waterproof form of outlet-box used out of doors, or in other places where the conditions require the use of a watertight and waterproof outlet-box.

It will be seen in this case, that the box is threaded for the conduits, and that the cover is screwed on tightly and a flange provided for a rubber gasket.

Figs. 38 and 39 show water-tight floor boxes which are for outlets located in the floor. While the rules do not require that the floor outlet

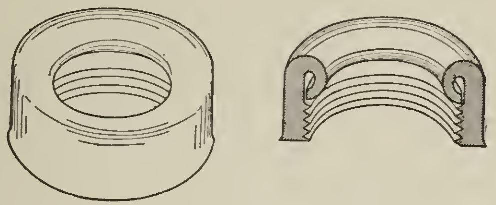


Fig. 40. Conduit Bushing

box shall be water-tight, it is strongly recommended that a water-tight outlet be used in all cases for floor connections. In this case also, the conduit opening is threaded, as well as the stem cover through which the extension is made in the conduit to the desk or table. When the floor outlet connection is not required, the stem cover may be removed and a flat blank cover be used to replace the same.

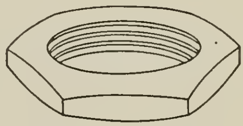


Fig. 41. Lock-Nut

There is hardly any limit to the number and variety of makes of outlet-boxes on the market, adapted for ordinary and for special conditions; but the types here illustrated are characteristic and typical forms.

Bushings. The *Rules of the National Electric Code* require that conduits entering junction-boxes, outlet-boxes, or cut-out cabinets

Fig. 42. Panel-Box Terminal Bushing

shall be provided with approved *bushings,* fitted to protect the wire from abrasion.

Fig. 40 shows a typical form of conduit bushing. This bushing is screwed on the end of the conduit after the latter has been introduced into the outlet-box, cut-out cabinet, etc., thereby forming an insulated orifice to protect the wire at the point where it leaves the conduits, and to prevent abrasion, grounds, short circuits, etc. A lock-nut, Fig. 41, is screwed on the threaded end of the conduit before the conduit is placed in the outlet-box or cut-out cabinet, and this lock-nut and bushing clamp the conduit securely in position. Fig. 42 shows a terminal bushing for panel-boxes used for flexible steel conduit or armored cable.

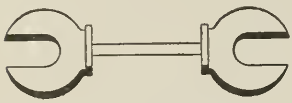


Fig. 43 Copper-Tipped Fuse Link

The *Rules of the National Electric Code* require that the metal of conduits shall be permanently and effectually grounded, so as to insure a positive connection for grounds or leaking currents, and in order to provide a path of least resistance to prevent the current from finding a path through any source which might cause a fire. At outlet-boxes, the conduits and gas pipes must be fastened in such a


Fig. 44. Edison Fuse-Plug

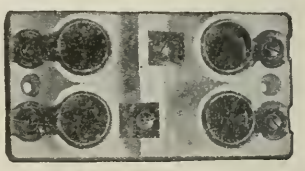


Fig. 45. Porcelain Cut-Out Block

manner as to insure good electrical connection; and at centers of distribution, the conduits should be joined by suitable bond wires, preferably of copper, the said bond wires being connected to the metal

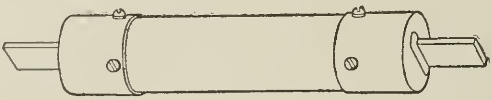


Fig. 46. Enclosed or "Cartridge" Fuse

structure of the building, or, in case of a building not having an iron or steel structure, being grounded in a permanent manner to water or gas-piping.

Fuse-Boxes, Cut-Out Panels, etc. From the very outset, the necessity was apparent of having a protective device in circuit with the conductor to protect it from overload, short circuits, etc. For this purpose, a fusible metal having a low melting point was employed. The form of this fuse has varied greatly. Fig. 43 shows a characteristic form of what is known as the *link fuse* with copper terminals, on which is stamped the capacity of the fuse.

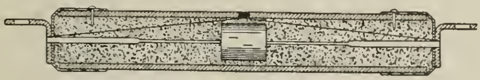


Fig. 47. Section of Enclosed Fuse

The form of fuse used probably to a greater extent than any other, although it is now being superseded by other more modern forms, is that known as the *Edison fuse-plug,* shown in Fig. 44. A porcelain *cut-out block* used with the Edison fuse is shown in Fig. 45.

Within the last four or five years, a new form of fuse, known as the *enclosed fuse,* has been introduced and used to a considerable

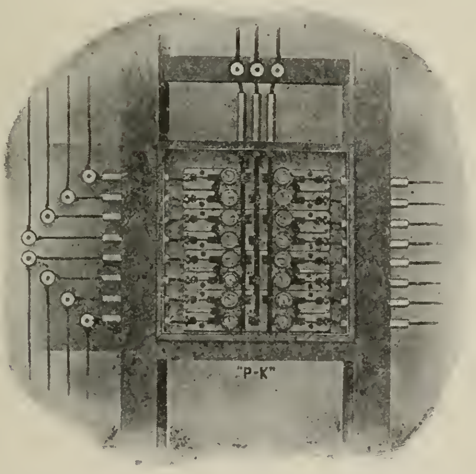


Fig. 48. Porcelain Cut-Outs in Wooden Box

extent. A fuse of this type is shown in Fig. 46. Fig. 47 gives a sectional view of this fuse, showing the porous filling surrounding the fuse-strips, and also the device for indicating when the fuse has blown. This form of fuse is made with various kinds of terminals; it can be used with spring clips in small sizes, and with a post screw contact in larger sizes. For ordinary low potentials this fuse is desirable for currents up to 25 amperes; but it is a debatable question

TABLE VI

Carrying Capacity of Wires

B. & S. Gauge	Circular Mils	Rubber Insulation	Other Insulation
		Amperes	Amperes
18	1,624	3	5
16	2,583	6	8
14	4,107	12	16
12	6,530	17	23
10	10,380	24	32
8	16,510	33	46
6	26,250	46	65
5	33,100	54	77
4	41,740	65	92
3	52,630	76	110
2	66,370	90	131
1	83,690	107	156
0	105,500	127	185
00	133,100	150	220
000	167,800	177	262
0000	211,600	210	312
	200,000	200	300
	300,000	270	400
	400,000	330	500
	500,000	390	590
	600,000	450	680
	700,000	500	760
	800,000	550	840
	900,000	600	920
	1,000,000	650	1,000
	1,100,000	690	1,080
	1,200,000	730	1,150
	1,300,000	770	1,220
	1,400,000	810	1,290
	1,500,000	850	1,360
	1,600,000	890	1,430
	1,700,000	930	1,490
	1,800,000	970	1,550
	1,900,000	1,010	1,610
	2,000,000	1,050	1,670

whether it is desirable to use an enclosed fuse for heavier currents. Fig. 48 shows a *cut-out box* with Edison plug fuse-blocks used with knob and tube wiring. It will be seen that there is no connection compartment in this fuse-box, as the circuits enter directly opposite the terminals with which they connect.

Table VI shows the allowable carrying capacity of copper wires and cables of ninety-eight per cent conductivity, according to the standard adopted by the American Institute of Electrical Engineers and must be followed in placing interior conductors.

For insulated aluminum wire the safe-carrying capacity is 84 per cent of that given for copper wire with the same kind of insulation.

The lower limit is specified for rubber-covered wires to prevent gradual deterioration of the high insulations by the heat of the wires, but not from fear of igniting the insulation. The question of drop is not taken into consideration in the above tables.

The carrying capacity of Nos. 16 and 18, B. & S. gauge wire is given, but no smaller than No. 14 is to be used, except as allowed under rules for fixture wiring.

ARC LAMPS

Electric Arc. Suppose two carbon rods are connected in an electric circuit, and the circuit closed by touching the tips of these rods together; on separating the carbons again the circuit will not be broken, provided the space between the carbons be not too great but will be maintained through the arc formed at these points. This phenomenon, which is the basis of the arc light, was first observed on a large scale by Sir Humphrey Davy, who used a battery of 2,000 cells and produced an arc between charcoal points 4 inches apart.

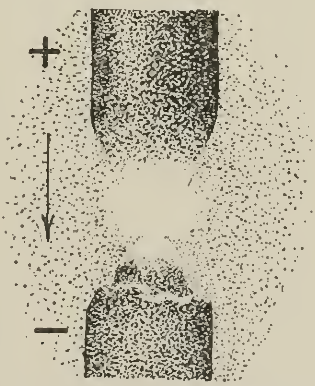


Fig. 49. The Electric Arc Between Carbon Terminals

As the incandescence of the carbons across which an arc is maintained, together with the arc itself, forms the source of light for a large portion of arc lamps, it will be well to study the nature of the arc. Fig. 49 shows the general appearance of an arc between two carbon electrodes when maintained by direct current.

Here the current is assumed as passing from the top carbon to the bottom one as indicated by the arrow and signs. We find, in the direct-current arc, that the most of the light issues from the tip of the positive carbon, or electrode, and this portion is known as the *crater* of the arc. This crater has a temperature of from 3,000° to 3,500° C., the temperature at which the carbon vaporizes, and gives fully 80 to 85 per cent of the light furnished by the arc. The negative carbon becomes pointed at the same time that the positive one is hollowed out to form the crater, and it is also incandescent but not to as great a degree as the positive carbon. Between the electrodes there is a band of violet light, the *arc proper,* and this is surrounded by a luminous zone of a golden yellow color. The arc proper does not furnish more than 5 per cent of the light emitted when pure carbon electrodes are used.

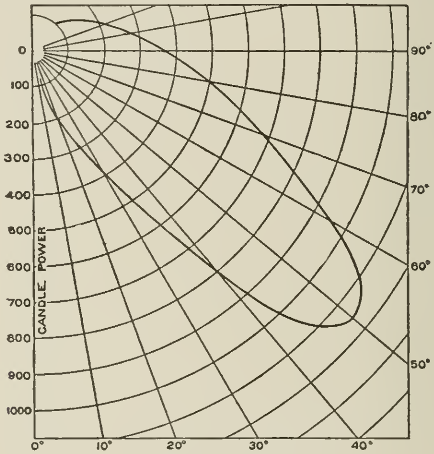


Fig. 50. Distribution Curve for D. C. Arc Lamp (Vertical Plane)

The carbons are worn away or consumed by the passage of the current, the positive carbon being consumed about twice as rapidly as the negative.

The light distribution curve of a *direct-current arc,* taken in a vertical plane, is shown in Fig. 50. Here it is seen that the maximum amount of light is given off at an angle of about 50° from the vertical, the negative carbon shutting off the rays of light that are thrown directly downward from the crater.

If alternating current is used, the upper carbon becomes positive and negative alternately, and there is no chance for a crater to be formed, both carbons giving off the same amount of light and being consumed at about the same rate. The light distribution curve of an *alternating-current arc* is shown in Fig. 51.

Arc-Lamp Mechanisms. In a practical lamp we must have not only a pair of carbons for producing the arc, but also means for sup-

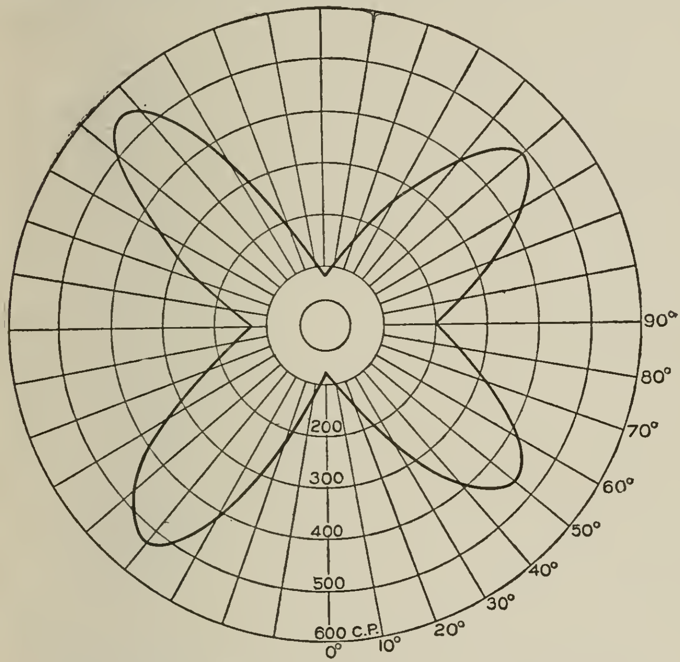


Fig. 51. Distribution Curve for A. C. Arc Lamp (Vertical Plane)

porting these carbons, together with suitable arrangements for leading the current to them and for maintaining them at the proper distance apart. The carbons are kept separated the proper distance by the operating mechanisms which must perform the following functions:

1. The carbons must be in contact, or be brought into contact, to start the arc when the current first flows.
2. They must be separated at the right distance to form a proper arc immediately afterward.
3. The carbons must be fed to the arc as they are consumed.
4. The circuit should be open or closed when the carbons are entirely consumed, depending on the method of power distribution.

The feeding of the carbons may be done by hand, as is the case in some stereopticons using an arc, but for ordinary illumination the striking and maintaining of the arc must be automatic. It is made so in all cases by means of solenoids acting against the force of gravity or against springs. There is an endless number of such mechanisms, but a few only will be described here. They may be roughly divided into three classes: shunt mechanisms, series mechanisms, differential mechanisms.

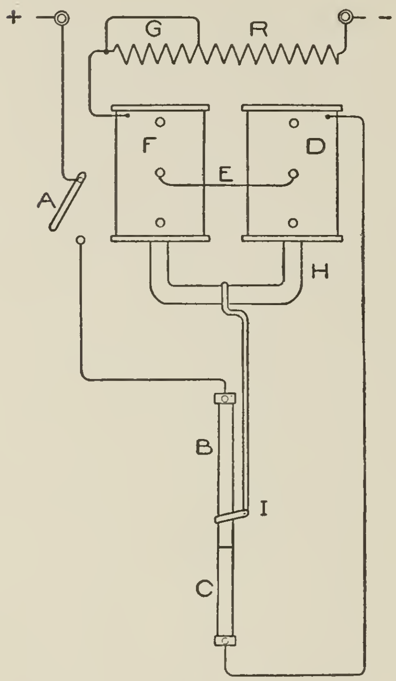


Fig. 52. Series Mechanism for D. C. Arc Lamp

Shunt Mechanisms. In shunt lamps, the carbons are held apart before the current is turned on, and the circuit is closed through a solenoid connected in across the gap so formed. All of the current must pass through this coil at first, and the plunger of the solenoid is arranged to draw the carbons together, thus starting the arc. The pull of the solenoid and that of the springs are adjusted to maintain the arc at its proper length.

Such lamps have the disadvantage of a high resistance at the start—450 ohms or more—and are difficult to start on series circuits, due to the high voltage required. They tend to maintain a constant voltage at the arc, but do not aid the dynamo in its regulation, so that the arcs are liable to be a little unsteady.

Series Mechanisms. With the series-lamp mechanism the carbons are together when the lamp is first started and the current, flowing in the series coil, separates the electrodes, striking the arc. When the arc is too long, the resistance is increased and the current lowered, so that the pull of the solenoid is weakened and the carbons feed together. This type of lamp can be used only on constant-potential systems.

Fig. 52 shows a diagram of the connection of such a lamp. This diagram is illustrative of the connection of one of the lamps manufactured by the Western Electric Company, for use on a direct-current, constant-potential system. The symbols + and − refer to the terminals of the lamp, and the lamp must be so connected that the current flows from the top carbon to the bottom one. *R* is a series resistance, adjustable for different voltages by means of the shunt *G*. *F* and *D* are the controlling solenoids connected in series with the arc. *B* and *C* are the positive and negative carbons respectively, while *A* is the switch for turning the current on and off. *H* is the plunger of the solenoids and *I* the carbon clutch, this being what is known as a *carbon-feed lamp.* The carbons are together when *A* is first closed, the current is excessive, and the plunger is drawn up into the solenoids, lifting the carbon *B* until the resistance of the arc lowers the current to such a value that the pull of the solenoids just counter-balances the weight of the plunger and carbon. *G* must be so adjusted that this point is reached when the arc is at its normal length.

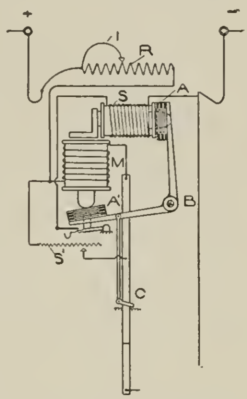


Fig. 53. Differential Mechanism for D. C. Arc Lamp

Differential Mechanisms. In the differential lamp, the series and shunt mechanisms are combined, the carbons being together at the start, and the series coil arranged so as to separate them while the shunt coil is connected across the arc, as before, to prevent the carbons from being drawn too far apart. This lamp operates only over a low-current range, but it tends to aid the generator in its regulation.

Fig 53 shows a lamp having a differential control, this also being the diagram of a Western Electric Company arc lamp for a direct-current, constant-potential system. Here *S* represents the shunt coil and *M* the series coil, the armature of the two magnets *A* and *A'* being attached to a bell-crank, pivoted at *B*, and attached to the carbon clutch *C*. The pull of coil *S* tends to lower the carbon while that of *M* raises the carbon, and the two are so adjusted that equilibrium is reached when the arc is of proper length. All of the lamps are fitted with an air *dashpot,* or some damping device, to prevent too rapid movements of the working parts.

The methods of supporting the carbons and feeding them to the arc may be divided into two classes: rod-feed mechanism, carbon-feed mechanism.

Rod-Feed Mechanism. Lamps using a rod-feed have the upper carbons supported by a conducting rod, and the regulating mechanism acts on this rod, the current being fed to the rod by means of sliding contact. Fig. 54 shows the arrangement of this type of feed. The rod is shown at *R*, the sliding contact at *B*, and the carbon is attached to the rod at *C*.

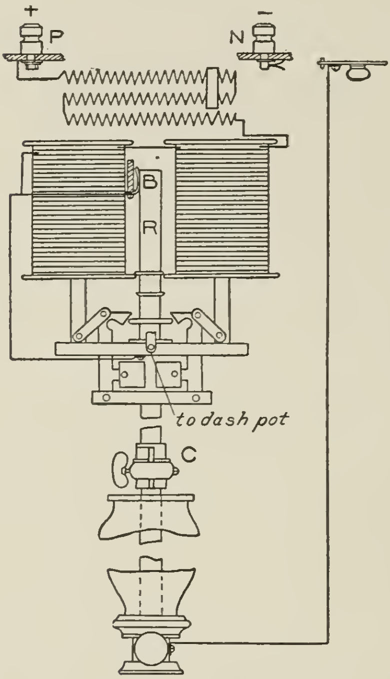


Fig. 54. Rod-Feed Mechanism

These lamps have the advantage that carbons, which do not have a uniform cross-section or smooth exterior, may be used, but they possess the disadvantage of being very long in order to accommodate the rod. The rod must also be kept clean so as to make a good contact with the brush.

Carbon-Feed Mechanism. In carbon-feed lamps the controlling mechanism acts on the carbons directly through some form of clutch which grips the carbon when it is lifted, but allows the carbon to slip through it when the tension is released. For this type of feed the carbon must be straight and have a uniform cross-section as well as a smooth exterior. The current may be led to the carbon by means of a flexible lead and a short carbon holder.

MOVING-PICTURE MACHINES

Arc Lamp. Arc lamp used as a part of moving picture machines must be constructed similar to arc lamps of theaters, and wiring of same must not be of less capacity than No. 6 B. & S. gauge.

Arc lamps used for stage effects must conform to the following requirements:

a. Must be constructed entirely of metal except where the use of *approved* insulating material is necessary.

b. Must be substantially constructed, and so designed as to provide for proper ventilation, and to prevent sparks being emitted from lamps when same is in operation, and mica must be used for frame insulation.

c. Front opening must be provided with a self-closing hinged door frame in which wire gauze or glass must be inserted, excepting lens lamps, where the front may be stationary, and a solid door be provided on back or side.

d. Must be provided with a one-sixteenth-inch iron or steel guard having a mesh not larger than 1 inch, and be substantially placed over top and upper half of sides and back of lamp frame; this guard to be substantially riveted to frame of lamp, and to be placed at a distance of at least 2 inches from the lamp frame.

e. Switch on standard must be so constructed that accidental contact with any live portion of same will be impossible.

f. All stranded connections in lamp and at switch and rheostat must be provided with approved lugs.

g. Rheostat, if mounted on standard, must be raised to a height of at least 3 inches above floor line, and in addition to being properly enclosed must be surrounded with a substantially attached metal guard having a mesh not larger than 1 square inch, which guard is to be kept at least 1 inch from outside frame of rheostat.

h. A competent operator must be in charge of each arc lamp, except that one operator may have charge of two lamps when they are not more than 10 feet apart, and are so located that he can properly watch and care for both lamps.

Miscellaneous. *Rheostats* must conform to rheostat requirements for theater arcs.

Top reel must be encased in a steel box with a hole at the bottom only large enough for film to pass through, and cover so arranged that this hole can be instantly closed. No solder to be used in the construction of this box.

A *steel box* must be used, for receiving the film after being shown, with a hole in the top only large enough for the film to pass through freely, with a cover so arranged that this hole can be instantly closed. An opening may be placed at the side of the box to take the film out, with a door hung at the top, so arranged that it cannot be entirely opened, and provided with spring catch to lock it closed. No solder to be used in the construction of this box.

The *handle* or crank used in operating the machine must be secured to the spindle or shaft, so that there will be no liability of its coming off and allowing the film to stop in front of lamp.

A *shutter* must be placed in front of the condenser, arranged so as to be readily closed.

Extra films must be kept in metal box with tight-fitting cover.

Machines must be operated by hand (motor driven will not be permitted).

Picture machine must be placed in an enclosure or house made of suitable fireproof material, be thoroughly ventilated and large enough for operator to walk freely on either side of or back of machine. All openings into this booth must be arranged so as to be entirely closed by doors or shutters constructed of the same or equally good fire-resisting material as the booth itself. Doors or covers must be arranged so as to be held normally closed by spring hinges or equivalent devices.

*MERCURY=ARC RECTIFIERS FOR MOTION PICTURES

One of the most important factors contributing to the success of a motion-picture theater is the quality and brilliancy of the light projected from the lamps. For pleasing effect motion pictures require a steady, white light of sufficient intensity to bring out the natural light and color values of the films, and the theater having the best quality of light stands the best show of getting the biggest patronage. It is well known that the light obtained from the direct-current is much superior to that from the alternating-current arc lamps. However, until recently all those who could obtain only alternating-current supply have got along with the poorer quality of light simply for the lack of apparatus for economically converting alternating current into direct current.

In Fig. 55 is shown a mercury-arc rectifier developed by the General Electric Company for furnishing current of the desired character at a cost less than that of the most economically operated alternating-current arc lamp.

There are certain facts which should be borne in mind while making an analysis of the cost of producing a given intensity of projected light from alternating current, direct current, and rectified

*By courtesy of the McGraw Publishing Company.

A LETTER FROM HIS MOTHER
Scene from Photoplay, "Col. E. D. Baker—1st Cal."
Courtesy of the *Champion Film Company, New York*

current with the most approved devices applicable in each case. For instance, the best class of motion pictures requires a light intensity of upward of 8,000 candle power, and as 5,000 candle power is the maximum obtainable from alternating current with the best auto-transformers, or the highest current values practicable, it is evident that the use of alternating current under such conditions is

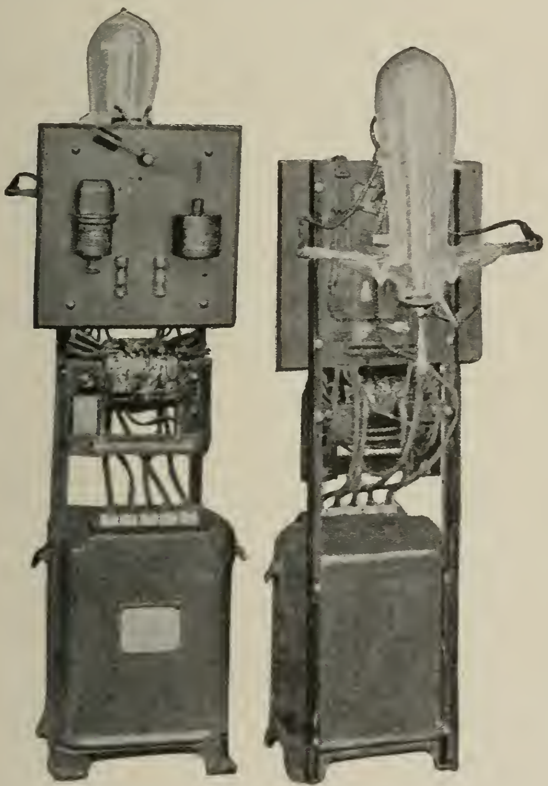


Fig. 55. Front and Back Views of Mercury-Arc Rectifier for Moving-Picture Machine

entirely satisfactory owing to the insufficiency of the light. Where direct-current supply is obtainable, some have found relief by using it, but their experience has served to emphasize the prohibitory effect of the additional cost entailed by the loss of at least 60 per cent of the energy drawn from the line in the resistance or rheostat employed to regulate the current in the arc.

These facts serve to define the limitations of both the alternating-current and the direct-current arc relative to motion-picture lighting, but in order to give the various alternating-current methods a fair basis for comparison, assume that a light intensity of 5,000 candle power is required. From actual determinations carefully made it is found that to obtain 5,000 candle power from a 110-volt alternating-current circuit with rheostats requires 7 kilowatts; a 110-volt direct-current circuit with rheostat requires 2.25 kilowatts; any alternating-current circuit with auto-transformer requires 2.1 kilowatts, and with mercury-arc rectifier requires 1.7 kilowatts.

Since auto-transformers are extensively used in alternating-current supply systems to obtain a substantial reduction in energy consumption, the method of using alternating current with rheostats may be considered as obsolete, and since a prohibitory amount of energy is wasted in using direct current with a rheostat, that method can be omitted from present consideration. This affords a direct comparison between the alternating current with the use of economizers on the one hand and mercury-arc rectifiers on the other.

The figures given above show a difference of 400 watts in favor of the mercury-arc rectifier. This means than on the basis of an average daily run of seven hours at a cost of 6 cents a kilowatt-hour the use of a mercury-arc rectifier provides a light having all the advantages of that given by a direct-current arc at a cost of at least $60 per year less than that obtained from alternating current with the best type of auto-transformer.

Furthermore, it is evident that when the light intensity required exceeds 5,000 candle power, thus rendering the alternating-current method inapplicable, the saving effected by the use of the mercury-arc rectifier as compared to the cost of using direct current with a rheostat is much more significant. For instance, to obtain 7,500 candle power requires 3.1 kilowatts from direct current with rheostat and 2.15 kilowatts from alternating current with mercury-arc rectifier. The difference in favor of the mercury-arc rectifier is 950 watts, which means a saving of at least $145 per year.

In addition to the positive money-saving capability of the device, the excellent light of practically any candle-power obtainable from alternating-current supply and the reliability, ease, and safety of operation render the mercury-arc rectifier particularly desirable for making pleasing and successful "photo plays."

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