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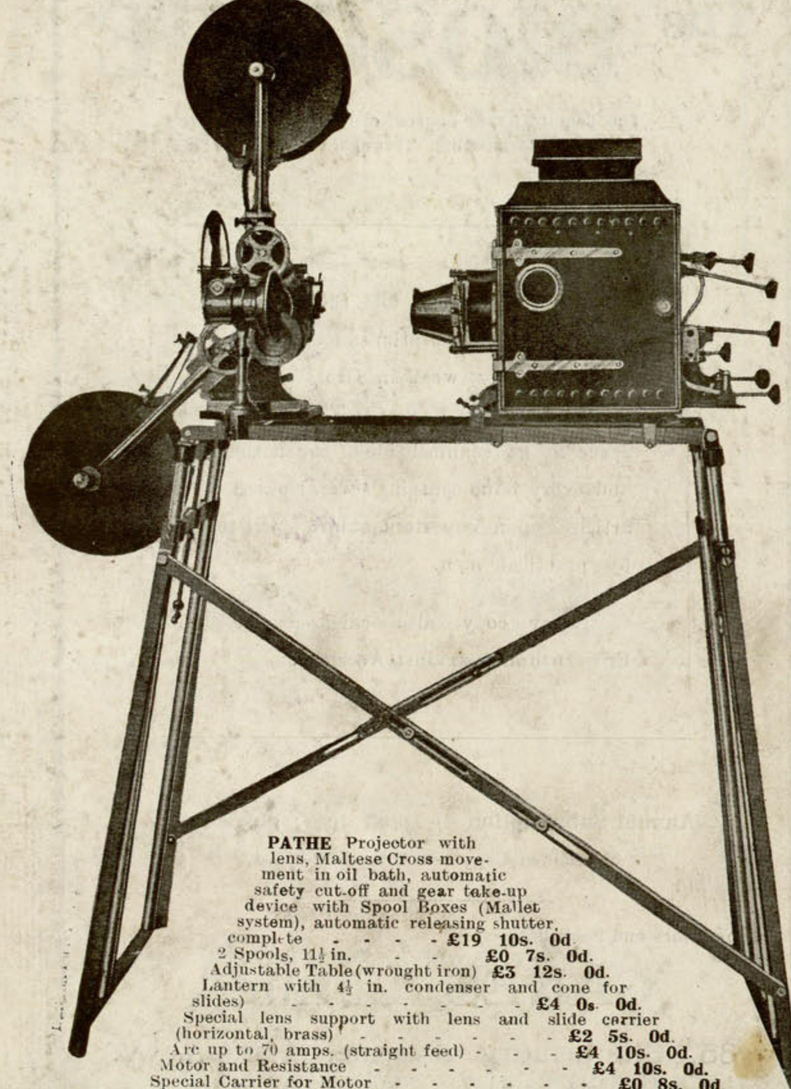

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THE MODERN BIOSCOPE OPERATOR

SECOND EDITION.

LONDON:
GANES, LIMITED
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1911.

PUBLISHERS' PREFACE

The Publishers offer no apology for the appearance of THE MODERN BIOSCOPE OPERATOR. For a considerable time past such a book, which would be thoroughly reliable and of assistance to the large number of men now pursuing their daily avocation in the Moving Picture Industry, has been eagerly sought after. Considering that this is the only publication of the kind in this country, the Publishers have reason to believe that it will be a boon and a blessing to the multitudes of Bioscope Operators and Managers of Picture Theatres, both in the United Kingdom and abroad. It is written by men who have been in the business since its infancy, so that we are, in the circumstances, justified in throwing off the publisher's characteristic modesty in this Preface. With these few words of introduction we send forth THE MODERN BIOSCOPE OPERATOR on its career of usefulness.

London,

February, 1910.

PREFACE TO SECOND EDITION

The Moving Picture Industry has made such rapid strides during the last fifteen months that even our most optimistic anticipations regarding the sale of this book have been greatly exceeded, and the whole of a very large Edition has been sold practically without effort on our part. In the present Edition it has been considered advisable to alter the sequence of the various chapters and to re-write and add to several of them. The chapter on Electric Lighting has been greatly extended, and now includes a number of pages on Petrol-driven Generating Sets and Rotary Transformers.

London,

May, 1911.

CONTENTS.

CHAPTER I.

INTRODUCTION.

1. *Origin of the Moving Picture*—2. *Muybridge's Experiments*—3. *The First Public Exhibition of Pictures*—4. *Birt Acres*—5. *Lumière*—6. *Underlying Principles*—7. *Persistence of Vision*—8. *The Ideal Operator.*

THE origin of the moving picture, like that of gunpowder, is lost in mystery; and the more we trace the history backwards to try and arrive at its real start, the more difficult it is to know where to stop.

The fact is, that the moving picture, as we have it at the present day, contains such a remarkable number of inventions, and is composed of, and dependent upon, so many scientific facts and principles, that a treatise several volumes in length would be required to deal completely with the subject.

The idea of moving pictures can be traced back through the Kinetoscope by way of the old-fashioned Zoetrope, or Wheel of Life, to the Thaumatrope, which in itself was exceedingly simple; but even then we are not at the root of the matter, or at least it seems not, for recently the idea has been propounded that on a Greek tablet has been found a record which leads one to suppose the existence of moving pictures before the year 100 B.C.

But putting this aside, as perhaps after all, the merest conjecture, we come back to modern times, and feel safe in making the definite statement that the one great item which made possible the moving picture show as we have it at the present day, was the discovery of a transparent flexible substance suitable for use as a vehicle for supporting a sensitive photographic film. Celluloid, after all, was the greatest factor in this long list of inventions, and although plates of glass have been made and used in such a way as to produce a moving picture of a kind, the present perfection was quite unattainable by such means. Many years of experiment and research resulted in the presentation of moving pictures; Marey, a Frenchman, obtained photographs of birds with the idea of elucidating the problem of flight; Muybridge, an Englishman, then domiciled in America, carried out an exhaustive series of experiments to determine the movements of man and animals; Anchutz, a German, also worked at the same problem; and Edison, with the Kinetoscope, proved it possible to photograph ordinary scenes and afterwards view them in natural motion; but none of the productions gave us the living picture as we have it now. Muybridge, indeed, showed his pictures on the screen, so that a large audience could view them, and his method was, without doubt, the first to attain this object.

His pictures were silhouettes, and showed no detail beyond the determination of the outline, and the illumination of the screen was faint, but sufficient to prove the scientific theories which he advanced. Celluloid was not then invented, and his pictures were on glass plates, and each only included one complete cycle of the gait of an animal; as, for instance, the stages passed through during a complete series of steps taken by a horse when walking, trotting, galloping, or jumping. Although many inventors were at work for a long time, and despite the fact that machines were approaching perfection, some having been shown privately (one exhibition being that of Mr. Birt Acres before our late King, then Prince of Wales, at Marlborough House, in November, 1895), the first practical and popular performance was given at the Empire, Leicester Square, in 1896, and it was reserved for a Frenchman, M. Lumière, to make the first decided mark in the long journey through which this machine had to travel before success, even of a poor kind, was attained. Within a very short period innumerable exhibitors appeared on the scene, some of whose productions were good, but this could not be said of the bulk. Nevertheless, the bioscope, as an attraction at this time, was considered a star turn, and the usual question was: "Have you seen the moving pictures yet?" The exhibition was such a revolution and was such a decided advance on anything that had been previously seen, that a host of inventors, photographers and mechanics applied their ingenuity to the subject, with the result that within little more than a decade the industry has attained its present colossal proportions.

The principle underlying the moving picture is as follows: If you look at anything an impression of that object is retained in the eye for a certain length of time, more or less according to the illumination of the object. This is particularly the case with brilliantly lighted objects, which, so to speak, saturate our vision for a small period. Professor Tindall first came to the conclusion that the time of the persistence of an impression on the retina was one-sixteenth of a second—that is, the impression would remain for one-sixteenth of a second after the object had disappeared. It is by taking advantage of this fact that the moving picture has become possible, the application of it being as follows:—A succession of photographs, each slightly different from the preceding one, is presented to the eye, at the rate of about sixteen per second; the resulting appearance being a continuous picture. Where the machine used is a good one, the pictures are of course nearest perfection and without flicker, but if the machine is inferior the resultant pictures flicker considerably and do not present the continuity aimed at. These pictures are projected by an optical arrangement, by means of which enlarged images of the photographs on a long strip of transparent celluloid film are thrown on a screen. The principle, however, of the moving picture is fairly well known, and it is not

here proposed to enter into a scientific dissertation upon the underlying principles, but rather to instruct the operator in the successful manipulation of his apparatus.

The enormous increase in the number of bioscope theatres throughout the United Kingdom creates a constant demand for a large number of skilled operators. Every bioscope machine requires the attention of an operator—a man who is competent to obtain the best results from the machine placed under his care. He must know every detail of his mechanism; what to do in an emergency and the quickest way of doing it, so as not to keep his audience waiting a moment longer than is absolutely necessary; he must be acquainted with all the latest and best methods of projection; the care of films, optical principles and fire appliances. He must also be able to obtain the best results under difficult circumstances, and be competent to fit up his apparatus at a moment's notice.

He should be proficient in the use and treatment of any illuminant with which he may have to work. For the arc light he must be familiar with a certain amount of electrical science, and acquainted with some of the rules for its measurement of power and the application of resistances. To deal successfully with the limelight he must know the main facts governing the compression of gases; and a small amount of chemical knowledge must be added to this to enable him to deal with the mixing and burning of oxygen and hydrogen in combination. He must have some small mechanical knowledge, and should be skilled in the use of ordinary tools in order to be able to repair, or at any rate to patch together, a breakdown in the machinery should such occur. The ideal operator should be possessed of a cool head, and should at all times have sufficient confidence in himself and his methods to act promptly and sensibly in case of emergency. This latter quality cannot be acquired by book-reading or study. Knowledge combined with practice will inspire confidence in cases where either of these qualities, applied separately, will be useless; it is therefore necessary that of all men the bioscope operator must be well grounded in all the main principles and theories underlying his craft, and it is with the intention of setting out these principles simply and clearly that the compilation of the following pages has been undertaken.

CHAPTER II.

THE FILM.

1. *Celluloid, its Inflammability*—2. *Non-Flam Film*—3. *Effect of Heat*—4. *Care of Films*—5. *Cleaning*—6. *Handling*—7. *"Rain"*—8. *Storing Films, Effect of Heat and Damp*—9. *Joining Films*—10. *Film Cement*—11. *Threading Film Through Projector*—12. *Rewinding*—13. *Blank Spacing.*

THERE is one point which a bioscope operator must never lose sight of, and that is the highly inflammable character of the film. Familiarity breeds contempt, and in handling film daily, month after month, and year after year, one is all too apt to become careless; but the least carelessness when a film is on the projector is really criminal. Although but a few inches of film may accidentally ignite, the resulting blaze is quite sufficient to start among an audience a panic which may have the most disastrous results; therefore before the commencement of any exhibition of moving pictures, the bioscope operator should assure himself that there is no loose film in his box, or anywhere within the hall where there is any possibility of its being ignited. The regulations prescribed by Parliament, and enforced by the Municipal Councils, have done much for the safety of the audience; in fact, have made the picture show so safe that it is much less liable to endanger the audience than is the ordinary theatrical performance. Nevertheless, the operator cannot be too careful—he is the one now most likely to be hurt in case of fire.

Celluloid, the substance of which the base of the film is made, is, in its chemical constitution, very nearly akin to gun-cotton. No absolutely successful substitute in all qualities suitable to replace celluloid has been discovered to the present time. Three different forms of non-inflammable film have been introduced, but as they do not seem to make much headway in the market there is probably more work to be done before an altogether satisfactory substance to take the place of the inflammable celluloid film will be found. The operator may be called upon, now and then, to use non-flam film. There is little to be said in the way of special instruction, except that it should be protected from heat in the same way as the ordinary film, not because of any danger of inflammability, but owing to the fact that the heat will spoil it and cause it to shrivel up, and even a moderate amount of heat will make it decrease in length and width enough to cause trouble by the perforations becoming too close to properly fit the sprockets of the machine, owing to shrinkage.

It is necessary, in giving a bioscope show, to use a powerful light, and this is not obtainable without its due proportion of heat. In order to use the light

to its best advantage, it must be concentrated by means of a condensing lens, which also acts as a burning glass, directing the heat on to the film. As long as the machine is working and the film is moving, no danger of burning the film need be feared, but a pause in the action of the machinery, or a piece of torn film remaining still for a few seconds in the path of the light and heat rays, may cause a fire, the results of which cannot be estimated.

THE CARE OF FILMS.—The life of a film depends to a great extent upon the care of the operator and the condition in which he keeps his machine, his spools, and the floor of his projecting box. One of the most fruitful causes of scratching and marking of films is the exceedingly bad, yet common, habit of rapidly and loosely winding up the roll and then pulling out the loose end so as to tighten up the inner portions. The result of this is that any grit or sharp particles of dust that may have accumulated on the film while it was passing through the machine are simply ground on to the emulsion surface of the easily damaged film. No lanternist, for instance, would ever dream of taking two unbound lantern slides and rubbing their film surfaces together as hard as he possibly could; and yet this is what a great many operators are in the habit of doing with their films, and the fault is, as often as not, put down to the mechanism of the bioscope.

From time to time all films require cleaning—that is to say, the celluloid side must be wiped gently and carefully with a soft cloth, very slightly moistened with methylated spirits; a cleaning board can be easily made from a piece of timber, say 9 in. wide and 3 ft. long, covered with a double thickness of swans-down, which can be procured from any draper for a few pence. Upon this the film is placed, the emulsion side downwards, and the back carefully rubbed with the soft moistened cloth. Never under any circumstances touch the centre of the film with your fingers; all handling should be done at the edges, where, should any finger marks be left, they will not harm the picture itself. From the celluloid side marks can be easily removed; the emulsion side is not so easy to deal with. Moisture, perspiration, or a drop of water or oil, will usually leave permanent marks on the emulsion, and such marks, when magnified on the screen, especially when they occur in a clear sky picture, become unpleasantly noticeable and give a ragged and slovenly effect.

Grooves also get worn into the celluloid side, and becoming filled with dust, cause the effect known as "rain," so often a prominent feature in badly used films. Cleaning the dust out of the grooves improves their appearance in a remarkable manner. When grooves or lines occur on the emulsion side, little or nothing can be done to get rid of them. Be careful in cleaning the emulsion side not to use much pressure, and be very particular that the material used for this purpose is quite free from grit, or the "cleaned" state of your film will be worse than

before the cleaning was attempted. Should oil get upon the film it must be immediately removed, or by its accumulating dust, which will grind on the gate surfaces, scratches will result. Benzoline or petrol will quickly and safely dissolve the oil without harm to the film, and if removed immediately, no harm will be done.

When you have to store films for a long period, it is not advisable to put them in a hot, dry place. A cool, fairly dry cellar is a good situation, and should they show any tendency to become hard or brittle a slightly damp place, such as a cellar or outhouse, will be a suitable store. If very brittle, they may be removed from the tin box and wrapped in brown paper, but should be examined every few days to see if pliable enough. Too much damp may affect the emulsion, and if the film has not been well washed during manufacture, efflorescence of the chemical salts may appear on the gelatine. Should a section of film become torn it will be necessary to repair it, or it may be necessary to join up several subjects together into one spool; for this purpose a thick ½ in. plate glass cutting shape, such as is used by most photographers, will be found useful, or a plate of hard steel; the writer prefers glass as being more cleanly. A fairly sharp penknife and a short steel rule will be necessary as tools, also a small camel hair brush and a bottle of film cement, which generally consists of amyl acetate in which a few pieces of celluloid have been dissolved; although some prefer to use the acetate alone. Acetone is also a solvent of celluloid; but the use of acetate of amyl is recommended, as it dries quickly and is much cleaner to use than some of the gluey cements that are on the market. When treating non-flam film it is best to use the special cement recommended by the makers of the film; the ordinary acetate cement will not be found effective..

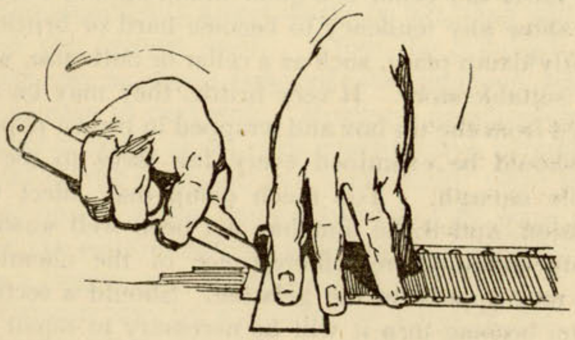


FIG. 1.

Care must be taken, when mending or joining up films, that the space in which the join occurs is properly placed in relation to the preceding and subsequent pictures, otherwise a jump will occur, and the picture move up or down on the screen, so that a part of the next picture will be visible. To make a join, take one of the pieces of film, and with a sharp pair of scissors trim square the end, so that it ter-

minates exactly at the end of one of the pictures. Now take up the other section to be joined, and cut it square across, leaving about $\frac{1}{8}$ in. to $\frac{1}{4}$ in. beyond the end of the complete picture, to form an overlap. Slightly moisten the emulsion side of the overlap with the tongue, and then, using the steel rule as a guide, scrape away with a penknife all the emulsion so as to leave the overlap quite clean and free from

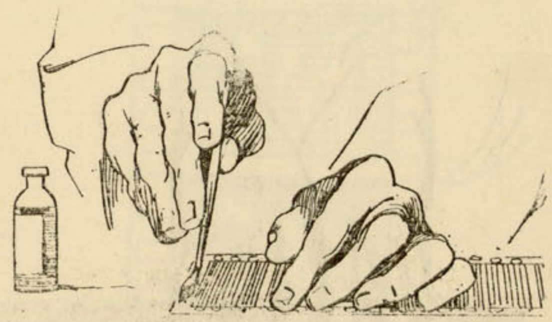


FIG. 2.

gelatine. Now, with the camel-hair brush, paint this overlap with acetate of amyl, and also the corresponding area of the *back* of the other piece of fi'm. Bring the two cemented surfaces into contact and press them tightly together for a few moments till they adhere perfectly, taking care to see that the overlap perforations correspond, and that there are four perforations to the picture next to which the join has been made. Run your fingers along the edge of the join, and carefully trim off any slight projections. A glance at Figs. 1, 2 and 3 will show the whole process of repairing broken films, and Fig. 4 shows the exact position of the join. This method of joining up applies equally, of course, to the insertion of film titles.

The novice is generally rather uncertain in his mind as to which end of the film is to be threaded

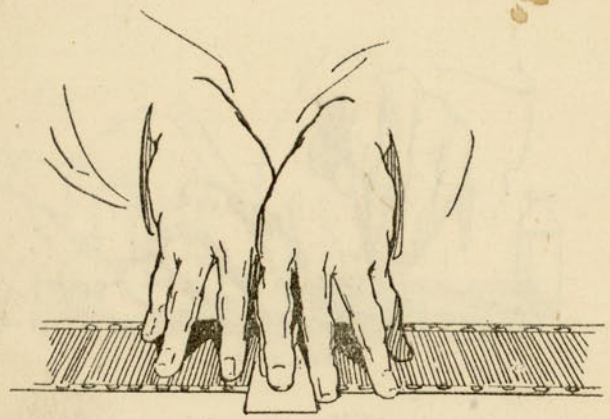


FIG. 3.

through the bioscope, and which side is to be placed towards the screen. The film must always be threaded through the machine with the coated side towards the condenser, so that the subject, as the picture stands in the gate, is upside down; the picture will then appear upon the screen the right way up. When it is necessary to show the picture

through the screen, the film must have its gelatine surface turned towards the audience, otherwise the titles and any lettering on the picture will appear on the screen the wrong way round. In rewinding films after they have been through the machine, see that they are placed upon the spool so that the finish of the picture is the first part to be wound on the reel; then, when the spool is placed on the machine for projec-

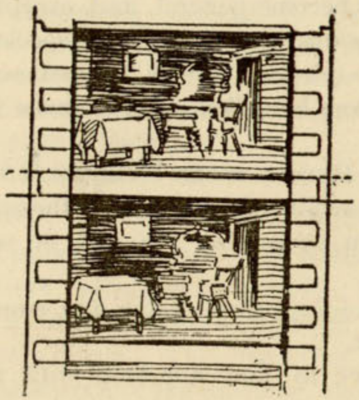


FIG. 4.

tion, the film will naturally thread through the gate upside down.

It is now the universal custom for the programme of films to be joined up in series and wound on one or more spools, according to the duration of the exhibition; and between each subject must be inserted a foot or two of blank spacing—*i.e.*, opaque film, which prevents the dazzling white sheet appearing at the end of each subject. Nearly all firms now send out their films with the title printed on them, so that there is no necessity to use a special slide in introducing them, but as this is not at present quite universal, and as the operator may receive or have to make up spools minus any titles, he must be prepared to make title slides at short notice. Since the above was written, the practice of providing titles to all films has become general, and, except for the purpose of announcing anything of special interest to the audience (election results, for instance) the operator will seldom be called upon to make slides for the lantern.

Points to be Remembered.

Wind your films fairly tight on the spools. Don't tighten them by pulling the end, or scratches will result.

When joining, don't leave *any* emulsion on the scraped part.

Don't try to join non-flam with the ordinary cement.

Don't wind a lot of film on spool before being certain that you are starting at the proper end.

Don't forget that ordinary film is INFLAMMABLE.

CHAPTER III.

The Projecting Apparatus.

1. *The Mechanism*—2. *The Sprockets*—3. *The Intermittent Action*—4. *The Take-up Mechanism*—5. *The Shutter*—6. *Spools and Spool-boxes*—7. *The Automatic Cut-off*—8. *The Gate*—9. *The Projecting Lens*—10. *The Lantern or Lamp-house*—11. *The Condenser*—12. *The Hand Cut-off and Slide Carrier*—13. *The Lantern-slide Attachment.*

THE MECHANISM.—The mechanical part of the apparatus may be divided in three distinct parts, distinct only on account of the different classes of work they are called on to perform, these parts being geared by wheels, bands or chains, and working together as a whole. The projecting lens also is fixed to the framework of the machine, as are also the spool boxes, the shutter, and the automatic cut-off.

1. The Sprockets.—In all machines two sprockets will be found: the "upper" or feed sprocket, and the "lower" or take-up sprocket. In a small number of machines a third sprocket is used, and this is interposed between the normal lower sprocket and the take-up spool. The reason for this will be given in the chapter concerning the theoretical explanation of the mechanism.

2. THE INTERMITTENT ACTION.—This part of the machine deals with the portion of the film between the upper and lower sprockets, and causes it to move forward in a succession of jerks.

3. THE TAKE-UP MECHANISM.—This is situated at the lower part of the machine, to which it is geared sometimes by a band, or a chain, and sometimes by bevel wheels. Its function is to wind up the film as it leaves the machine, and it is provided with a friction device, by which the increasing sized roll of film is allowed to turn more slowly as it becomes larger while the winding proceeds.

The three parts described above are common to all projecting machines, and their functions are also identical in all.

THE SHUTTER.—The shutter, which is a necessary part of all projectors at present in use, differs considerably in different designs of machine; it has undergone many changes during the last few years. Changes and alterations in the arrangement of the shutter are still taking place, and much doubt as to the best form yet remains. The shutter usually consists of a rotating plate, placed in the path of the rays of light which pass from the condenser through the film and the projecting lens, to the screen. Its location varies in different makes of machine, being sometimes between the condenser and the film, sometimes between the film and the projecting lens, but more often it is placed beyond the projecting lens. In some few machines two rotating plates are used.

Whatever form the shutter takes it is so arranged that no light reaches the screen while the film is in motion. Shutters of various shapes all have one blade or section for the purpose of cutting off the light, as above stated. Extra blades are often added with the idea of minimising "flicker"; these extra blades vary in number and size, and are usually opaque, but occasionally transparent and colored.

The foregoing description comprises all the parts which can be classed as *essentials* in projecting mechanisms.

SPOOLS AND SPOOL-BOXES.—For convenience in handling the films spools are used, 12 in. diameter being the general size. These hold from 1,200 to 1,400 ft. of film, according to its thickness and pliability. This size of spool is the largest that can be conveniently used in spool-boxes, the diameter of which is limited to 14 in. by Parliamentary regulations. Spool-boxes are fixed to the framework of the machines, and are provided with mouthpieces for the egress or admission of the films. Devices of various designs are fitted to the mouthpieces, with the idea of preventing the firing of the film on the spool should the portion of film passing through the machine accidentally become ignited. Closely-fitting rollers or automatically-closing spring-flaps are generally supplied.

THE AUTOMATIC CUT-OFF.—A small shutter, designed to fall and cut off the light (and heat) from the film, is placed between the condenser and the film.

This is operated by some form of centrifugal governor, and is so arranged that should the machine by accident or defect cease to work, or should its rate of working become slow, the shutter automatically fails and cuts off the light and heat from the slowly moving or stationary piece of film, which being in the path of the rays of light and heat would otherwise take fire.

THE GATE.—This is the portion of the machine through which the intermittently moving part of the film passes. It is here that the picture is illuminated and the film is held flat, so that the image on the screen may be properly focused or made sharp. Springs or pressure plates, called "skates," hold the film in place, and on the adjustment of the pressure of these springs (or skates), as the case may be, much of the excellence of the performance depends. Special instructions for the adjustment of the gate are given later.

THE PROJECTING LENS.—This lens forms the image which is seen on the screen. It is provided with an adjustment (usually a rack and pinion), by which its distance from the film may be easily and quickly set.

THE LANTERN OR LAMP-HOUSE.—The shape and proportions of the lantern or lamp-house vary considerably in different makes of projector. It consists of a case, usually of iron, sometimes lined or covered with asbestos, and is arranged to slide in grooves or fittings, so that its distance from the projecting mechanism may be varied. Its use is to enclose the illuminant, carry the condensing lens and hand cut-off, and to protect the operator from the direct light and heat of the arc-lamp or lime-jet, as the case may be. Some lamp-houses are provided with chimneys or ventilators; others depend upon the opening at the back to carry away the heat. Another use for the lamp-house is to protest the inside glass of the condenser from draughts, which are a fruitful source of breakages.

THE CONDENSER.—Held in the front wall of the lamp-house is the condensing lens, the purpose of which is to collect as much light as possible from the illuminant and cause it to pass through that portion of film in the aperture of the gate. The condenser is easily removable, because when using powerful illuminants the inner glass nearest to the light is very liable to crack, and it is at times necessary to replace a glass without loss of time.

THE HAND CUT-OFF AND SLIDE-CARRIER.—These are fixed close to the condenser, outside the lamp-house. The hand cut-off is a very important accessory; on its proper and prompt use depends the danger—or otherwise—of the performance. It is arranged to shut off all light (and heat) from the machine, and must be kept closed at all times when the machine is at rest. The automatic cut-off must not be relied upon to perform this office, as, being rather delicate in construction it *may* fail at a critical moment. The regulations require that an automatic cut-off be fitted to every machine, but the operator is here advised to regard it as merely an additional safe-guard, and to consider that he, and he only, can save the situation by the use of the hand cut-off, should trouble occur. 'Sometimes the lantern slide carrier (which usually has two openings for the reception of the lantern slides, so that one slide can be changed during the time the other one is being shown on the screen) is made to do duty as a hand cut-off, by placing a plate of metal in one of its apertures. The slide-carrier is used only in conjunction with the lantern-slide attachment, described hereuder.

THE LANTERN-SLIDE ATTACHMENT.—To the frame-work of many mechanisms is fixed an arm, into which lantern lenses may be screwed. When this is the case, means are provided by which this lens may be brought into the direct path of the light rays, either by swinging the whole mechanism round on a pivot, or by sliding either the mechanism or the lamp-house itself to one side. A lantern-slide being placed in the slide-carrier, its image can then be focused on the screen by means of the lantern lens, in the same way as the film is dealt with by the smaller or projecting lens. These two lenses are similar in their construction, and only differ in their focal lengths, which should be in the proportion of about 3½ to 1.

THE COMPLETE APPARATUS is fixed on a solid base of iron or some non-inflammable material, and is usually provided with means by which it may be raised or depressed at one, or in some cases either end.

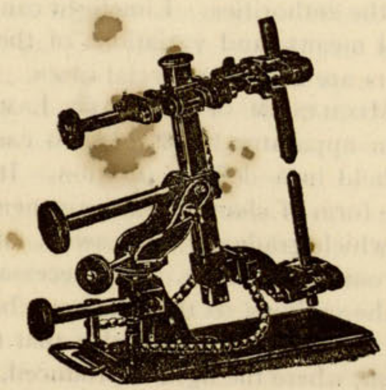
CHAPTER IV.

THE ILLUMINANT.

1.—*The Mechanism of the Arc Lamp.*
2.—*The Lime Jet and its Adjustments.*

IN order to produce a good effect on the screen a powerful light is absolutely necessary. Whenever possible, electric light is made use of, but failing this, recourse must be had to limelight, these two methods of illumination being the only ones sanctioned by the authorities. Limelight can be produced by several means, and variations of the general arrangements are useful in special cases.

THE MECHANISM OF THE ARC LAMP.—The arc lamp is an apparatus by which two carbons can be securely held in a definite position. It is provided with some form of clamping arrangement to hold the carbons, which gradually burn away, and require renewing from time to time. It is necessary to be able to move the carbons so that they can be adjusted to a definite distance apart, and also that the space between them, where the light is produced, can be made to always occupy a definite position with reference to the condenser, in spite of the fact that they continually wear away during use. Arc lamps vary considerably in design; most of those used in England, however, follow one general principle. The base on which the mechanism is fixed is arranged to slide into the lamp-house from the rear, running in guides, and the distance from the condenser is regulated merely by pushing in or pulling out the lamp. In a few cases screws or racks are provided for this adjustment. The top or positive carbon holder has means of moving that carbon to or from the condenser by turning a knob which actuates a screw. Another knob causes the two carbons to advance towards one another in order to compensate the amounts consumed; also turning this knob will cause the carbons



to touch one another when the arc has to be "struck" at starting. This knob is known as the "feed." The whole arrangement containing the feed mechanism and that for advancing the top carbon is mounted

on a device for raising or lowering this part as a whole; the knob working this movement is called the "elevator." There is yet another knob which, on being turned, causes both carbons to move to the right or left, and this is termed the "traverser." It will thus be seen that in relation to the condenser, the carbons can be moved towards or from it, up or down, and right or left; also that the carbons can be separated or brought together, and that the top or positive carbon can be kept exactly in a line with the bottom or negative carbon, or can be made to take a position more or less behind it. All the adjustments work independently, and the alteration of any one does not alter the setting of the rest. Reference to the illustration on the previous page will make this clear.

The complete mechanism is usually furnished with an adjustable joint, by which the lamp may be set upright or sloped backwards, as may be required. The adjusting knobs project from the rear of the lamp-house when the lamp is in position for use.

THE LIME JET.—The adjustments provided for the lime jet are somewhat different from those of the arc lamp. The light is produced by directing on to a cylindrical block of quick-lime a burning mixture of oxygen and hydrogen gases. The adjustments for movement of the illuminant, up, down, forward, backward, and right or left, are often effected in exactly the same manner as in the arc lamp. The other adjustments required in the lime jet are as follows:—The lime cylinder can be moved near to, or far from the flame, sometimes by a knob working a screw, and sometimes by a simple clamping arrangement. The lime is mounted on a pin, which passes through its centre, and as it becomes worn hollow by the jet of gas, a new surface can be presented to the flame by turning a knob at the back. This actuates the pin carrying the lime, and as it turns it also rises, so that a succession of new surfaces placed spirally round the cylinder are presented to the flame. There are also two valves or taps for regulating the two gases, and many jets are provided with a cut off, by turning which the oxygen gas is completely stopped, while only a small amount of hydrogen is allowed to pass. This cut-off is a very useful attachment, as it allows of all adjustments of gas being made before it is required to use the light, and after they are made the light can be extinguished and re-established without disturbing the adjustment, the small amount of hydrogen serving to keep the lime warm and the jet alight and ready for use at a moment's notice. Lime jets vary much in their internal construction, some having a large mixing chamber, in which the gases combine, and some depending upon the principle of the injector to effect the mixture. The mixing chamber is provided with a number of pieces of wire gauze, or a series of pierced plates, and among these travelling through and in, the gases become intimately mixed. Some few jets have a combination of the two systems.

CHAPTER V.

THE MANAGEMENT OF LIMELIGHT.

1\. *Different Types of Jet*—2. *The Mixed Jet*—3. *The Injector Jet*—4. *Lighting Up*—5. *Obtaining the Correct Mixture*—6. *Treatment of Limes*—7. *Compressed Gas Cylinders*—8. *Regulators and Gauges and their Treatment*—9. *Method of Attachment to Cylinders*—10. *Reading the Gauge*—11. *Treatment of Tubing*—12. *The Fine Adjustment Valve*—14. *Points to be Remembered.*

TWO standard types of jet are used in the production of limelight, varying in the details of their construction. These two types of jet are known respectively as the mixed jet and the injector jet.

In the first, the "mixed jet," the oxygen and coal gas (or hydrogen), both under pressure, mix in the "mixing chamber" of the jet itself just before ignition.

In the second, the "injector," the hydrogen passes through a fairly large tube, surrounding a nozzle, from which issues the oxygen gas at a pressure higher than that of the hydrogen, and the mixture is effected in a small chamber or tube leading to the nozzle where the gases burn.

A great advantage possessed by the injector jet is that it requires only the oxygen supply to be under pressure; the coal gas may be drawn from the ordinary house supply. For efficiently working this jet, the oxygen must be delivered to it at a pressure of from 12 lb. to 15 lb. per square inch, therefore it is essential to employ a suitable regulator on the oxygen cylinder to deliver the gas at this pressure, which is, of course, considerably higher than that required for ordinary mixed jets. With this increase of pressure it is imperative that stronger tubing be used between the regulator and the jet than would be used with the mixed jet. The ordinary india-rubber tubing suffices for connecting the coal supply with the injector jet.

In working a limelight there are some few points always to be borne in mind. They apply in all cases, and must be carried out invariably, no matter what particular kind of jet may happen to be in use.

In starting, turn *on* Hydrogen first.
In extinguishing, turn *off* Oxygen first.
Always start with a considerable flame of Hydrogen before adding Oxygen.

Neglect of any of these conditions may mean a "snap," or small explosion in the jet itself; no particular danger attaches to this, but it should be carefully avoided, because nervous people in the audience may think that something serious has happened, and should anything go wrong later, the nervous tension of the audience being already high, may conduce to a state of panic, which in all cases must be guarded against.

Another thing may also result. If the mixture passing into the jet at the time when a "snap" takes

place should be in such proportions that the burning of the mixture inside the jet continues, the internal arrangements of the jet will be burned up and the performance stopped unless another jet is in reserve. Whenever a "snap" occurs, immediately turn off the oxygen tap, and no harm will result. With ordinary care a "snap" should never take place unless the jet is out of order, when it should at once be returned to the maker for repair.

A leaky "cut-off," or an accumulation of foreign matter in the mixing chamber or tubes of a mixed jet, may cause liability to snapping or firing back, and the same condition may be produced in the injector form if the oxygen nozzle should become partially stopped up.

When lighting up a lime jet, first see that all taps connected with the jet are turned off; next set the cut-off to the open position, then, having turned on the cylinders—or, in the case of the injector jet, the gas from the main and oxygen cylinder—proceed as follows: Turn on sufficient hydrogen to give a good flame, then gradually turn on the oxygen, doing this at first slowly to let the air contained in the tube escape. This will take perhaps ten seconds, when the addition of the oxygen will cause the lime to give out some light. Continue adding oxygen as long as the light increases in intensity, and when this increase ceases, try adding some more hydrogen, and continue with one or the other gas until roaring starts. This means that one or both gases are turned on too full, when one and then the other must be slightly turned off until the noise ceases and a good result is obtained. This process must be gone through steadily and without hurry if the best result is to be attained, bearing always in mind that the best light is not necessarily produced by the use of the greatest amount of gas. Perfect and proper mixture, and a proper amount of that mixture, are the ideals to be aimed at.

So much for the treatment of the gases as they pass into and out of the jet. We must now look at the lime cylinder, on to which the flame of the mixed gases is caused to play.

The lime cylinders are supplied in air-tight tins, which, when opened for the removal of a "lime," should be immediately closed, in order to keep the atmosphere (which always contains moisture in this country) away from the limes. See that the hole through the lime is sufficiently large to pass easily over the lime-pin, and if not, make it so before proceeding further, or the expansion of the lime-pin, due to heat, may crack the lime in half, and cause it to fall off.

Moisture in any form is detrimental to the limes and should be carefully avoided. Before starting to light up, the lime should be heated, either by putting it close to a fire—on the bars, for instance—or by first lighting up the jet with an old or half-used lime in position, making the same red hot, and after turning out the light, placing the new lime on the top of the heated one for a minute or two. If—as is often done—the hydrogen flame be allowed to play

on to a cold lime for the purpose of heating it, a certain amount of moisture given off by the flame will be absorbed, and the lime be much more liable to crack than if the procedure recommended above be carried out. When starting, put two or three more limes in the lantern below the condenser, where they may be heated by the rays from the lime in use; then, if an accident occurs to the lime, another hot one is available. Do not forget to see that all fit easily on the pin. A long French nail, smaller in diameter than the lime-pin, but having its point hammered flat till it produces a hole of a suitable size, makes a serviceable and cheap tool for use with the limes, and one should always be carried in the kit of the operator. Having produced the best light possible by following the foregoing instructions, it is probable that the illumination may be still further increased by a proper adjustment of the distance between the surface of the lime and the nozzle of the jet.

An oxy-hydrogen flame is not in itself calculated to give any light; it will be seen to consist of two distinct parts, the outer a purplish diffused flame, and the inner a small sharp green cone, the inside of which consists of unburnt mixed gas. Should the lime cylinder be close enough to touch this green cone, a black spot will be produced on the lime at the place where the unburnt gases impinge, and the cold gases will probably cause the lime to crack at this point. A slight hissing noise will also be produced. If the lime be too far away the best light will not be given out. To adjust the lime, first be sure that it is too far away—say ½ in. from the nozzle—then gradually bring it nearer and nearer, till it touches the green cone and the hiss is heard. A little movement back from this point will place the lime in its best position. It will be seen that the lime-pin is arranged to turn, and also to work up and down by means of a rather coarse screw cut upon its spindle. This is to allow the operator to expose to the flame from time to time a new and unused surface of lime. Start with the lime in the lowest position and work upwards, turning the lime each time, just so much as will bring an unused portion into action. This must be done every minute when very powerful jets are in use, but is less frequently required with smaller jets. If this point is not continually attended to, broken condensers will be many, because the lime becomes pitted while being used, and after a time bcomes so shaped as to cause the flame from the nozzle to turn back and play upon the condenser. with disastrous results.

After the above-mentioned points have been attended to, the centring of the light may be done, but it is useless to attempt to centre the light until the proper adjustment of gases and the distance of the lime from the jet have been determined.

Nottingham limes are the hardest and most durable for use with the mixed and injector jets.

There are a good many high-pressure and injector jets upon the market, therefore the bioscope operator or the lanternist should have little trouble in finding one to meet his requirements. It is quite impos-

sible here to enter into a description of, and a discussion on, the merits and demerits of the numerous jets now offered for sale, but a word of advice may not be out of place.

Avoid cheap jets, they are often unsatisfactory; a good jet will pay for itself over and over again in reliability and wear, and well-fitting taps or valves make working a pleasure instead of an anxiety.

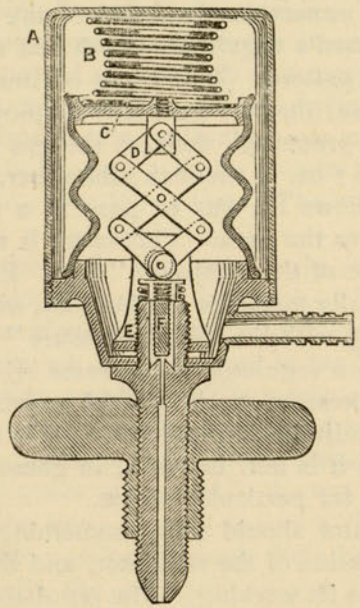
In describing the method of dealing with jets, the gases have been referred to as oxygen and hydrogen; in place of the latter, coal gas is now generally used. It gives slightly less light than pure hydrogen, but its cheapness easily pays for the extra consumption necessary to do the same work.

Oxygen, hydrogen, and coal gas are supplied compressed in cylinders, which contain large supplies of gas in a portable form.

The cylinders manufactured by the leading gas compressors in England, the British Oxygen Company, Limited (Brinn's Oxygen Company), of Elverton Street, Westminster, are absolutely safe, both for carriage by rail or van, and in use. This firm has spared no expense in carrying out the most exhaustive, costly and elaborate experiments, so as to ensure the highest perfection of workmanship, selection of material and testing. Moreover, they make it a rule, whether a customer orders it or not, to periodically overhaul and test the cylinder. The British Oxygen Company's oxygen cylinders are all fitted with the right-handed thread. while those for coal gas have a left-handed one. This precaution makes it absolutely impossible for an employee to fill a cylinder that has contained oxygen with coal gas, or *vice versâ;* for the screws will not fit, and cannot be made to do so. In this way all possibility of danger from the highly explosive mixture of oxygen and hydrogen being formed in the cylinder, is prevented. No cylinder is allowed to leave the company's works until it has passed all the tests that comply with the Government regulations. Each cylinder, before being subjected to the hydraulic test, is annealed, a process to which every cylinder should be submitted about once in every four years. The cylinder, after annealing, is tested hydraulically to a pressure of $1\frac{1}{2}$ tons per square inch, and, as already said, this test is given annually to every cylinder. If a cylinder purchased or hired from the British Oxygen Company be examined, it will be seen to bear two distinctive marks and a number. The marks show that the cylinder has been annealed and tested in accordance with the Government regulations, while the number serves as a register as entered in the test books of the company, who keep by this means a life record of every cylinder passing through their hands. It is now practically the universal custom for all cylinders and gauges to be painted a distinctive colour, cylinders charged with oxygen being painted *black*, as are also the regulators and gauges intended for use with the oxygen cylinder; while cylinders charged with coal gas (or hydrogen), and the regulators and gauges for use with them, are painted *red*.

REGULATORS AND PRESSURE GAUGES.—When using gas from cylinders, regulators are nearly always employed to deliver the gas at a reduced pressure to the apparatus. Several forms of regulator have from time to time been placed on the market, but it will be unnecessary to speak of any but the one known as Beard's regulator, which has now become the standard pattern. Two types of Beard's invention are in use; the one generally employed, known as the "low pressure," delivers the gas with a presure of about 7 oz. to the inch; the other, the "high pressure," allows the gas to pass at a pressure of about 14 lb. to the inch. This latter is required for use with some of the "injector" jets. Extra strong tubing, specially made for the purpose, must be used when working with the "high-pressure" regulators. There is also a regulator of the same style in which the delivery pressure can be altered as desired. This is called the adjustable regulator, and is suitable for any purpose; it is not, however, in general use, and does not call for particular notice.

The operator should know something about the inner construction of the regulator, and the principle which governs its working. The regulator is really a form of reducing valve, and the delivery pressure is supplied by a spiral spring, which, pressing on a small collapsible reservoir or bellows, tends to force out its contained gas. When gas is admitted to the regulator by opening the cylinder valve, the bellows immediately expands and compresses the spiral spring; becoming full, it closes the regulator valve by means of the following arrangement. Inside the bellows, and attached by one end to the top of the same, is a lazy-tongs systems of levers, terminating at the other end in a pair of eccentrics, so placed as



to force the regulator valve down when the bellows becomes full, thus shutting off the supply from the cylinder.

When a stream of gas is allowed to issue from the regulator bellows, the main valve lifts, and enough high-pressure gas to keep the bellows extended is allowed to pass into it. When this stream is stopped

by turning off the tap on the jet, the bellows extends slightly, and in so doing completely closes the valve and shuts off the high pressure. On the previous page is a diagram showing the working parts of the regulator, which will be easily understood from the foregoing explanation.

The gas cylinders are fitted with screw valves and the outlets are provided with screws for the attachment of the regulators. The oxygen cylinders have ordinary or right-handed screws, the hydrogen cylinders left-handed screws. This is to prevent the possibility of a hydrogen cylinder being charged with oxygen, or *vice versâ*. The regulators for the respective gases are supplied with the corresponding right and left handed screws, so they cannot be attached to the wrong cylinders.

Gauges—frequently attached to the regulators—are used to indicate the amounts of gases in the cylinders. Most pressure gauges are constructed on the same principle as the ordinary steam gauge. Gas entering the gauge from a cylinder, passes into a bent steel tube which has no outlet. The pressure of the gas has a tendency to straighten this tube, and the relative amount of deflection is shown by the movement of a pointer across a dial marked to indicate atmospheres, or amounts of 15 lb. to the square inch. Cylinders are made of such a size that when charged with the amount of gas for which they are intended, the pressure gauge will indicate 120 atmospheres, or 1,800 lb. to the square inch. When a cylinder is half full, only half the said pressure (60 atmospheres) will be shown on the gauge, and proportionate indications show proportionate amounts. Thus a 40 ft. cylinder will contain 10 ft. of gas when the gauge points to 30 atmospheres; a 20 ft. cylinder will contain 15 ft. of gas when the gauge points to 90 atmospheres; a 12 ft. cylinder will contain 2 ft. of gas when the gauge points to 20 atmospheres, and so on.

Tables concerning this and other matters will be found at the end of the book.

In fixing the regulators or gauges, or fine-adjustment valves to the cylinders, proceed as follows: First screw the loose nut into the mouth of the cylinder to the extent of four turns. This is to be done without removing the nut from the screw stem of the regulator or other appliance. Then screw the regulator till the end reaches the seating in the cylinder, when a turn of the loose nut will fix the whole securely. Care should be taken that no dirt or grit is in the seating or on the end of the stem of the regulator, and this latter should always be guarded from injury. When packing regulators take particular notice that this part does not come in contact with anything hard, because if dented, it will be impossible to get a gas-tight joint; the same care should be taken with the stems of all appliances intended to be fixed to cylinders.

When the regulators are fixed to the cylinders, the next thing will be to see if the joints are good. Place the thumb tightly over the outlet pipe of the regulator, and with the cylinder key slowly turn the

valve about half a revolution to the left. If the regulator has a gauge attached, the hand of the gauge will go round to the amount of pressure in the cylinder, and the amount of gas can be ascertained. Bring your ear as near as possible to the screw-nut and listen for any escape of gas. Should a hissing noise be heard, turn off the gas and unscrew the loose nut slightly, and try the regulator in a new position, say a quarter of a turn forward or backward, and again tighten the nut. When all is tight, turn off the gas and connect pipes to the jet taps, seeing that the gases pass into the correct pipes of the jet. These are usually painted red and black, in agreement with the colours of the cylinders. The instructions for adjusting the limelight have already been given. See that no leaks take place at the ends of the tubes. In using high pressure with the injector jet it is usually necessary to tie the tubes on with string, and tying is occasionally required with the low-pressure tubes, especially when of large diameter. At times trouble occurs owing to the valve in the regulator not shutting off completely, due to dust or grit getting on the valve seat; the flexible part of the bellows then usually blows off or bursts. The first condition may be rectified by unscrewing the brass case and retying, but the second-named accident cannot be repaired without the maker's help.

Many operators carry fine adjustment valves for both cylinders, in addition to the pair of regulators; which practice is much to be commended. The fine adjustment valve screws into the cylinder in precisely the same manner as the regulator. It consists of a screw valve similar to that of the cylinder, arranged to be operated by turning a large milled head. It is not liable to derangement of any kind, but requires to be opened slightly from time to time as the pressure in the cylinder decreases during the performance.

The valve screws in the cylinders and in the fine-adjustment valves are provided with right-hand threads for both oxygen and hydrogen. In dealing with screws it is well to remember that nearly all screws have right-hand threads. It is only for special purposes that a left-hand thread is used, and this is very seldom indeed. The hydrogen fittings are a case in point. On turning a right-hand screw to the right (or in the same direction as the hands of a clock travel) the screw goes *away* from the operator. *To close a cylinder or other valve* turn the key *the same way as the hands of a clock travel.* The same rule applies to screwing in an oxygen regulator, and to *nearly every other screw-fitting* or screw. The reverse applies to left-hand screws only.

When using fine-adjustment valves, *turn on full* both taps of the lime jet, and never close the cut-off. All regulation of the light must then be done by means of the fine adjustment valves, as the direct pressure of the cylinders would blow off or burst the tubes should adjustment then be attempted by means of the taps on the jet. The injector jet can also be equally well worked by means of this form of regulator; which, though

simple, reliable, and of small cost, is only used in cases of emergency, owing to the extra attention required to compensate for the reduction in the pressure of the gas during the gradual emptying of the cylinder. The regulator automatically allows for this reduction of pressure.

Some Points to be Remembered.

Don't let your limes get damp.

Be sure they do not fit the pin tightly.

Don't forget to start with a sufficiently large hydrogen flame.

Don't get your lime too near the jet nozzle.

Don't forget to turn your lime frequently, especially when using a large jet.

Take care of the flexible tubes, and do not kink them when packing up.

Don't turn on your cylinder valves with a jerk—you may burst the regulator bellows.

Don't forget to turn on your jet taps, and see that the cut-off is open when working with fine adjustment valve.

Don't forget to turn off oxygen at once when a snap takes place.

Don't dent your regulator ends.

See that the seatings into which they fit are clean.

Don't let oil get near your oxygen cylinder, and don't oil the valves.

Don't use grease of any kind on the screws of the regulator; black lead is harmless, and will make them run sweetly; a black-lead pencil rubbed on the threads will be sufficient.

CHAPTER VI.

TYPES OF PROJECTORS.

1. *Dog Movement*—2. *Mechanism of same*—3. *Maltese Cross Movement*—4. *Mechanism of same*—5. *Path of the Film*—6. *Advantages of this Movement*—7. *Pin or Claw Movement*—8. *Mechanism of same*—9. *The Three Movements Compared.*

IN the designing and making of projectors of new and improved forms there seems to be no finality. Week by week and month by month new models are introduced, all having real or supposed advantages over previously used forms, till it is very difficult to retain in one's memory the particular points claimed as advantages in the different machines.

Projectors differ considerably in detail, but in all machines there are parts which may be said to be common to all the instruments which throw the moving picture on to the screen.

In the design and arrangement of the intermittent movement great variation will be found, and it is this special part of the machine which distinguishes one style of projector from another.

The intermittent movement—that is, the part which forces the film to move forward in jerks—constitutes the essential difference found in projecting machines.

We may consider the parts common to all projectors as being: the upper and lower spools, the top and bottom sprockets, and the slipping device which allows the increasing-sized roll on the bottom spool to move at a suitable rate for winding up.

THE DOG MOVEMENT.—Let us take first the dog movement, as being the most largely used form, and describe its special features.

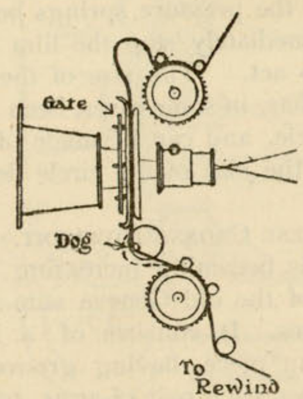


DIAGRAM OF DOG MOVEMENT.

In this form of machine, when the film has left the top spool, passed over the top sprocket, and formed a loop, it enters the gate, where the pressure springs hold it with a gentle friction, but nevertheless sufficiently tightly to prevent slipping. The film then passes under the dog and over the lower sprocket to the re-winding spool. The lower sprocket is, in many machines, fixed on the same spindle as the driving handle, and is rotated at a uniform rate. The dog rotates (in some of the older forms of machines it moved up and down) as many times during one revolution of the handle as pictures pass over the bottom sprocket in the same time. In each rotation of the dog the loop below the gate, which has become small by the rotation of the bottom sprocket, is brought to its original size by the passing of the dog, and thus one picture space is moved forward each time the dog comes round, the pressure springs being sufficiently strong to immediately stop the film as soon as the dog ceases to act. The size of the shutter of the dog machine has, in some cases, been reduced to one-sixth of a circle, and can be made of various sizes, according to the size of the circle described by the dog.

THE MALTESE CROSS MOVEMENT.—This arrangement, which is becoming increasing popular, is a development of the old Geneva stop-work, so much used in watches. It consists of a Maltese Cross shaped rotating piece, having grooves or slots cut through between each pair of arms, to the spindle of which is fixed a small sprocket wheel (in modern machines generally carrying four pictures to a revolution); this is driven intermittently by means of a pin, which is arranged to enter freely into one of the grooves when the said groove is placed exactly tangentially to the path of the driving pin, which is fixed on a disc, the spindle of which is driven at a uniform rate by the gearing of the machine. Another disc fixed in front of the previous one, having about one-

quarter of its circumference removed, is placed in such a position that its periphery enters an exactly corresponding curve formed in the ends of the arms of the Maltese Cross before described, just as the driving-pin leaves the groove. The whole arrangement is so placed that when the pin is in engagement with one of the grooves the Maltese Cross is free to

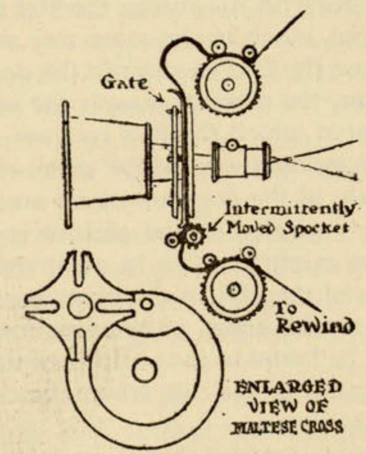


DIAGRAM OF MALTESE CROSS MOVEMENT.

turn, and when the pin is leaving the groove the disc, which fits the curve at the end of the arm of the Maltese Cross, has by its rotation so far entered the curve that it forms a lock which holds the cross from rotating until the pin enters the next succeeding groove.

The small sprocket, which is fixed to the spindle on which the Maltese Cross is also fixed, is caused to move intermittently by the working of the machine, turning each time when actuated by the driving-pin one-quarter of a revolution, and moving the film the space of one picture. The size of the shutter of this machine must be about one-quarter of a circle.

The film in this machine follows a path similar to that of the dog movement until it arrives at the lower part of the gate, where the small intermittently moved sprocket engages with it, causing the film to be pulled forward in jerks, much in the same way as the blows of the dog cause the film to move in the dog machine. It has, however, the advantage over the latter in that the exact point at which the film receives its impulse is placed very much nearer to the mask than can be done in the case of the dog movement machine; consequently, the variation of the picture is much reduced, and (as might happen in an inaccurate film) should a piece of the film in use contain perforations placed rather too far apart, or too near together, less difference will be found in the position of the resultant picture than would be the case where the dog was the actuating mechanism.

It will be very evident that if we take a piece of inaccurate film and apply it to a rule, a short piece will show less total variation from the normal than will a long piece. With absolutely accurate films and absolutely perfect machinery, the result obtained from either machine would be equally good. But perfection is very difficult to attain, and in all but the very best films inaccuracies exist and even the best are liable to inaccuracy, because celluloid is a very unstable substance, and may shrink as it becomes old, or expand under the action of moisture. If this variation took place quite evenly from end to end of the film no harm would result. It is, however, unlikely that the film will be of exactly the same thickness from end to end; in which case the thinner parts will be more quickly susceptible to the action of a damp atmosphere than will the thicker parts; consequently expansion will take place more at the former position. With the dog machine, a variation due to perhaps a length of 8 in. of film will become evident, while with the later forms of Maltese Cross machinery this distance will probably be reduced to less than 2 in. The relative variations will then be proportionate.

It will thus be seen that the Maltese Cross machine posseses great advantages over its older rival, and should time prove that its inherent liability to wear has been overcome, a great and increasing popularity is in store for it.

We now come to THE PIN MOVEMENT. This movement has still further advantages over the Maltese Cross movement. Classifying these machines under the head of pin movement is perhaps not quite fair, and a word of explanation may be necessary. Under the wide term of a pin movement we shall include all movements in which a single pair of pins, or claws, or several pairs of pins or claws, are moved in a path more or less rectangular.

In Lumière's original machine the path described by the points of the pins was almost exactly rectangular. Many machines have been introduced since in which the traverse of the pins varied considerably from the rectangular path, but in most cases the points were caused to move in a direction parallel with that of the film whilst in engagement with it. The same general arrangement obtains in this machine as in both the Dog Movement and the Maltese Cross machines, in that the top sprocket, the top loop, the

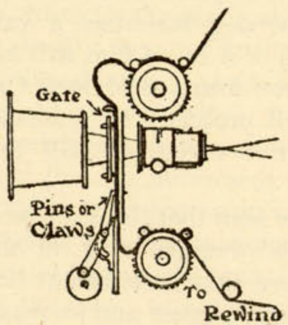


DIAGRAM OF PIN OR CLAW MOVEMENT.

gate, the bottom loop, and the bottom sprocket are exactly similar to the foregoing. Instead, however, of an intermittent sprocket or a dog for the intermittent moving forward of the film, a pair or a greater number of pins, or claws, are caused to enter the perforations, and having engaged with them, to move the film downwards an amount equal to the distance of one picture. The pins are then mechanically withdrawn and travel up to a position ready to again engage with the perforations, and the process is re-

peated. The mechanical arrangements by which the pins are caused to move are so very various that it would be fruitless to attempt to describe them in a short article. The general arrangement of the machine will be seen in the diagram on the previous page.

The film, after leaving the top spool, passing the top sprocket, forming the top loop, and entering the gate, is actuated by pins placed more or less close to the mask below the picture. The precise point at which the film is actuated may be a little farther from the mask than in the case of the Maltese Cross machine, and in this one particular machine has a disadvantage not possessed by the Maltese Cross machine. It has, however, one very great advantage, and that is that the mechanical movement actuating the pins, if properly made, will always cause them to leave the perforations of the film in exactly one and the same place. Now, in the case of the Maltese Cross machine, should the cross itself be inaccurately formed or untruly mounted on its spindle, or should the small sprocket be unevenly cut or untruly mounted on the spindle, No. 1 picture will be left in one position, No. 2 in a slightly different position, and No. 3 again with some variation, and No. 4 also inaccurate. The fifth picture will be left in exactly the same position as No. 1, so that only every fourth picture is certain to be properly registered. In the pin movement every succeeding picture will be left in perfect register. Extreme mechanical accuracy has made the Maltese Cross machine very excellent, but a pin machine has the advantage that with much less mechanical preciseness the perforations in the film will be all left exactly at the same position. The disadvantage, however, in all forms of pin machines hitherto constructed lies in the extreme difficulty of making the wearing parts (necessarily light) sufficiently strong and able to withstand the very heavy wear tc which they are subjected when in use. Mechanical excellence, however, may overcome this difficulty to a great extent, and the manufacture of these machines be so far improved that this disadvantage, which was possessed to a great extent by the Maltese Cross movement until recently, may be diminished or eliminated.

To sum up the whole question in as few words as possible: The dog movement machine is a rough and ready arrangement producing, when well made and when using perfect films, very fine results, and possessing the one very great advantage of non-liability to derangement in an extreme degree. Its registration is much spoiled by inaccuracy of perforation, and the difficulty of making the sprocket wheel (on which its registration depends) absolutely accurate, is great.

The Maltese Cross machine is calculated to produce at all times a result equal to that of the dog machine, and, in cases where inaccurate films have to be used, may be expected to give results very much finer than the previous machine.

The Pin machine, when in proper condition, will at all times show as fine a picture as the Maltese Cross

machine, but suffers from the disadvantage that its moving parts, being of a reciproating instead of a rotating description, are more liable to suffer from the jar and shake inseparable from backward and forward movement at a rapid rate. When new, these machines generally work excellently, but when worn soon develop inaccuracies which greatly mar the result on the screen.

The foregoing comparisons must not be taken too seriously. They are merely the result of experience in past years, and some of the new machines now approaching completion may possibly be so constructed as to diminish, if not to overcome, the disadvantages which have been referred to.

Since the foregoing was first published, the Maltese Cross machine has come rapidly into favour. Improved manufacture and better proportions of the Maltese Cross itself have rendered it nearly as reliable as the old dog or beater machine, so that at the present time it may be considered the standard form of projector, and is the one most usually met with. But it must not be considered that finality in projecting machines has been reached. Improvement is apparent on all sides, and the pin or claw machine—the most theoretically perfect—may yet be so modified as to become sufficiently durable to warrant its practical adoption.

It is interesting to note that a radical departure from previous practice has been made in an American projector which has recently been placed on the market in this country. There is no Pin wheel or Star wheel to this machine, the driving element being a diamond shaped revolving cam which actuates a cross that is rigidly mounted on the end of the intermittent spindle. A heavy pin is provided on the face of each arm of the cross for engagement with the cam, and the whole of the movement is enclosed in an oil bath. It is claimed for this machine that it considerably increases the steadiness of the picture.

CHAPTER VII.

THE ARC LAMP.

1. *Preliminary Adjustments*—2. *Fixing the Carbons*—3. *Striking the Arc*—4. *Centring the Light*—5. *Manipulation of Alternating Current.*

THE mechanism of the Arc lamp has already been described, and now we come to the method of using it, let it be impressed on the mind of the would-be perfect operator, that it is most important for perfect working that the lamp should be in good order. The various knobs and handles controlling the different adjustments should work comfortably and easily, but should not be too free in action. The elevator knob should be somewhat hard to turn—if too easily there is danger of the arc continually getting below centre owing to the vibration caused by working the projecting machine. The feed knob may with advantage work much more freely. The traversing movement and the adjustment for moving the top carbon out of line with the bottom carbon, should work with an amount of friction about intermediate between that of the "elevator" and the "feed." The operator should also see that the slide which holds the lamp in the lamp house works tightly, but without jerk. If too loosely fitted the carbons will easily get out of centre right and left, and if too tight, it will be found very difficult to place the light exactly at the right distance from the condenser, especially when, in a long show, the lamp-house and all it contains have become very hot. Although a good workman may turn out passable work when using indifferent tools, he will not disdain the finest implements he can procure; and although his productions may be good at all times, the general quality of his work and the ease with which he will produce it, will well pay for the extra cost of the finest implements, and for the time and care spent in keeping them in first-class condition.

Most modern lamps have means of taking up wear in the several moving parts, and as soon as any part of a lamp shows signs of slackness, immediate attention should be given to restore the lamp to its best working condition by tightening up the screws and fitting provided for the purpose. Carbon dust forms a specially gritty powder, and this has a tendency to get into all the moving parts of the Arc lamp, to the great detriment of all its adjustments.

When all connections have been properly made and the right amount of resistance placed in the circuit, the carbons must be suitably fixed in position.

Screw clamps of many different forms are provided for this purpose; it will not be necessary to descibe them in detail, and a moment's inspection will tell how they work.

Before fixing the carbons in position, see that the elevator is in the middle of its travel, and having racked the carbon holders as far apart as they will go, secure the top carbon so that its lower end shall be about half-an-inch higher than the centre of the condenser, and the lower carbon so that its upper end is about one inch away from the upper carbon. This is to be done before turning the switch to put the current on. Switch on the current, but no effect will be evident until the ends of the carbons are racked together till they touch. Immediately they meet a spark will be seen when they must be instantly separated to the distance of a quarter-of-an-inch, and the light will continue. This operation is called "striking the arc." It should be done promptly and with confidence, because if the carbons are allowed to remain in contact for even a very small amount of time, there is great danger of blowing a fuse, the renewal of which may cause delay. A tremendous rush of current takes place when the carbons are brought together, so the contact should continue for as short a time as possible. When striking an arc where a large current is to be employed, it is often necessary to introduce extra resistance into the circuit to prevent blowing the fuse; when the arc is established this extra resistance may be cut out, and the required current be allowed to pass. The arc being established it must next be "centred." To do this look at the circle of light thrown on to the gate shield of the machine, and by moving the elevator and traverser, make this circle concentric with the mask. It will be seen that the circle of bright light is surrounded by a ring of comparatively dull red colour, and by the size of this ring the distance of the light from the condenser may be adjusted. If the red ring be large and well away from the sides of the mask, the lamp must be moved away from the condenser; if on the other hand the red ring be so small as to touch the corners of the mask, the lamp must be moved forward. The white centre should quite cover every part of the picture opening, and the inner edge of the red ring be quite clear of the corners. This process should be gone through without troubling to look at the screeen, and with a very little practice it will be found quite easy to insure a good light on the picture by this means alone, but to be sure of obtaining the best possible effect, it is necessary to look at the screen and still further adjust the carbons should the illumination be uneven. Try turing each knob of the lamp to a very small amount one way and the other until the best result is obtained, and again take notice of the size and position of the red ring surrounding the gate. When it is necessary to again strike the arc, endeavour to produce a similarly placed light on the gate shield, and very little subsequent adjustment of centring will be necessary.

A small amount of practice will soon show what is the correct distance to which the carbons should be separated, and also the amount the top carbon should be out of line behind the lower one. Usually

when the carbons are too close together the arc makes a hissing noise and more light is obtained by increasing the separation. This is not invariably the case however. Practice is the only way to determine these points, and a little steady serious experimentalising will do more to teach the operator the best way to adjust the carbons than can all the written instructions in the world. Much may be learned by studying the ends of the carbons when burning, using a dark glass to protect the eyes from the glare. It will be seen that the top carbon gives out nearly all the light, and that this light proceeds from a comparatively small hollow that forms at the end of the top carbon. This is called the "crater." The lower carbon tends to form a point just opposite to this hollow. If the two carbons be kept in line with one another, the point on the lower and the crater on the upper carbon will form in the centre of the carbon rods. In order to persuade the crater to form somewhat sideways the carbons are thrown out of line, the upper one being moved farther from the condenser than the lower one. This causes the crater to face the condenser to some extent, and this effect is still further helped by sloping the lamp backwards to an angle of 15 to 20 degrees. In many lamps this slope is adjustable, but in some the apparatus is rigidly fixed at a definite angle. To help to keep the crater always in the same position the top carbon is cored, *i.e.* its centre is made of a softer composition than is the outer part. This softer carbon is consumed a little more easily than the rest, and the hollow in consequence keeps to the centre of the rod. The carbons must be fed towards one another from time to time to compensate for the consumption which goes on steadily. When the arc becomes too long, the light decreases and the crater tends to wander slightly out of centre, the light also flickers and becomes slightly blue in colour. When this occurs the carbons must be fed or the light will go out. It must not be forgotten that the positive carbon—*i.e* the top and cored one, must be twice the cross-sectioned area of the negative one. Tables showing the sizes of carbons will be found at the end of this book.

The foregoing instructions apply to the use of direct current. The top carbon should be in connection with the positive wire and the lower carbon with the negative. Should the wires be inadvertently connected in the reverse manner, the crater will tend to form on the lower carbon and will send the greater part of its light to the top and back of the lamp-house.

Direct current is always used when possible, and usually when the supply is of an alternating character, a device called a converter or motor generator is employed to change the current into the direct form. Sometimes it may be necessary for the operator to work with alternating current, and the following instructions apply only to this.

Much difference of opinion exists as to the best method of using alternating current, and the previous remarks as to the practice being necessary to enable one to successfully operate a direct current lamp, apply in an extra degree to the use of alternating current. As each carbon

is by turns positive and negative, a crater forms in the end of each. Both carbons (instead of only the top one) are of the cored variety, and several devices have been resorted to in order to overcome the tendency of the craters to wander from the desired position. Carbons with the cores placed near one side of the rod are sometimes used. Some operators are successful in using the ordinary cored carbons down one side of which a groove or flat has been filed. In any case the carbons must be placed in the lamp so that the thinnest parts of the hard outsides are towards the condenser, the idea being to cause the two craters to form on the side nearest the condenser. The lamp is placed so that the carbons are upright, and the ends are kept closer together than in the use of direct current. Hissing and singing noise in the arc must not be taken much notice of—the alternating arc always emits a considerable amount of noise, and the craters do not keep to the steady position as in the case of direct current. The arc is struck in the usual manner, and the carbons placed in a straight line one above the other. The carbons must be often fed or the crater will wander round and may sometimes form at the back of the carbons, when very little light will be obtained on the screen. The operator is advised to try his lamp for at least twenty minutes before starting to give a performance, and to notice at what separation the most *steady* light is obtained. He may, by manipulating the carbons, be able to increase the power of the light considerably for a time, only to find that all at once he can get little or none on to the screen until the carbons have burnt into a new shape. This often happens when too long an arc is used. In working an alternating lamp it is better to try for a *steady* light with a given current rather than a bright one, and when the distance at which the carbons burn steadily is found, to try and preserve the same distance apart of the ends of the carbons, feeding frequently by small amounts. Should more light be required than can be got at the " steady " distance, put on more current and increase the distance of the carbon points *very slightly*, watching carefully for the time when the craters show a tendency to wander. Alternating current working is always a " tricky " business, and considerable practice is necessary to insure confidence and certainty. A close attention to the facts above stated will do much to ground the would-be operator in the handling of this the most troublesome form of light for projection purposes.

CHAPTER VIII.

THE ELECTRIC INSTALLATION.

1. *Direct Current*—2. *Alternating Current*—3. *Volt*—4. *Ampere*—5. *Ohm*—6. *Ohm's Law*—7. *The Watt*—8. *Volt-meters*—9 *Ammeters*—10. *B.O.T. Units*—11. *Calculating Cost of Current*—12. *Insulation*—13. *Wiring*—14. *Pole Finding*—15. *Rheostats*—16. *Stand-by Resistances*—17. *Transformers*—18. *Auto-transformers*—19. *Choking Coils*—20. *Motor Generators*—21. *Rotary Converters*—22. *Auto-Converters*—23. *Comparative Costs*—24. *Petrol-driven Generating Sets*—25. *Accumulators*—26. *Care of Generating Plant*—27. *Commutator Troubles*—28. *Brushes*—29. *Lubricating*—30. *Switches*—31. *Water Resistance.*

ALTHOUGH bioscope apparatus has been so much improved that electric light is no longer an absolute necessity for obtaining the best results, except in large halls, the electric light should be used whenever it is available, not only because it gives a more brilliant light than any other illuminant, and is more reliable and efficient, but also on account of the extremely small size and great intensity of the illuminant area which can be obtained by it, which for optical reasons are important factors in obtaining perfection of results in projection. The bioscope operator should, therefore, make himself thoroughly conversant with the use of both direct and alternating electric currents.

DIRECT CURRENT (D.C.) flows constantly in one direction, therefore one carbon of the arc lamp is always positive while the other remains negative—that is to say, the current flows from the dynamo in which it has been generated along one wire (the positive), and having performed its allotted work, returns to the dynamo, *via* the negative wire. The positive carbon burns away considerably quicker than the negative one, so it has to be larger than the negative carbon, and in arcs used for lantern purposes is placed on top (see table in appendix).

With ALTERNATING CURRENT (A.C.) the flow is first in one direction and then in the other, so that both carbons of the lamp become alternately positive and negative; thus the current flows one way for a time, varied from 1-25th to 1-300th of a second, and then reverses and flows the same length of time in the opposite direction; the number of complete cycles per second is called the "Frequency" or "Periodicity" of the current. Thus when a frequency of 25 is spoken of, it means that the current flows 25 times in one direction, and 25 in the opposite one, and thus reverses its direction 50 times per second; while a 60 frequency would mean 120 reversals per second. In lighting systems the usual frequency met with is from 50 to 70.

For projecting purposes, ALTERNATING CURRENT (A.C.) can be made to yield results every bit as good as those obtained with direct current, but it requires more attention to the details of fitting up, and also

uses rather more current (amperes). The reason why alternating current is so much more frequently met with than D.C. is that it can be generated at a high voltage, and transmitted at a high pressure (voltage) to the place where it is to be used, and there transformed—*i.e.*, reduced to a lower voltage by means of a transformer. Moreover, A.C. is easily transformed back from a low to a high voltage. This ability to transmit at a high voltage means a great saving in the cost of the wires and cables required to carry the current, as the size of the wire depends only on the current to be transmitted and not on the voltage, but the work a given quantity of electricity can do depends both on the current and on the voltage. Hence a wire which will carry a current of 1 ampere at 100 volts will carry also a current of 1 ampere at 1,000 volts, but the former will only do one-tenth the work of the latter. Here comes in the advantage of alternating current, which can be transformed from one of high pressure or voltage to one of low voltage, and as one ampere at 1,000 can be transformed into approximately 10 amperes at 100 volts, we can obtain the equivalent of ten times the current along a given wire, when supplied at the high voltage and then transformed down.

In addition to A.C. and D.C., use has been made of the terms volt and ampere. It is important that the bioscope operator should fully understand and make himself thoroughly familiar with the meaning of the electrical terms volt, ampere, ohm and watt, as well as the difference between direct and alternating current already explained.

THE VOLT. In speaking of the pressure in a steam boiler, we say it is so many pounds per square inch. Now the term volt means exactly the same thing applied to electricity—namely, its pressure, and nothing but its pressure. Therefore, when we say that electricity is supplied at 200 volts, we mean 200 units of pressure.

THE AMPERE. This term means *volume* or *quantity* of current flowing per second, and is the unit used in measuring the rate of flow of a given quantity of current, in just the same way as gallons per hour or cubic centimetres per second are used for measuring the rate of flow of a quantity or volume of water flowing through a pipe.

THE OHM is the unit of *resistance*, and is the unit or part of that physical factor of a conductor which tends to obstruct or *resist* the passage of an electric current, and represents the resistance of a column of mercury (at 0 deg. Centigrade or 32 deg. Fahr.) of 1 square millimetre section, and 106.3 centimetres in length—*i.e.*, the resistance such a body of mercury would offer to current. The three units volt, ampere, and ohm, are connected in such a way that if a difference of pressure of 1 volt is applied to the two ends of the resistance of 1 ohm, a current of exactly 1 ampere will flow, which is expressed by what is known as

OHMS LAW—*i.e.*, the current equals the pressure divided by the resistance, and is expressed by means of the following formula :—

$$C = \frac{E}{R} \text{ or current in amperes } = \frac{\text{Pressure in volts.}}{\text{Resistance in ohms.}}$$

In all electrical matters the capital letter C always represents current in amperes, E means electromotive force, otherwise pressure in volts, and R signifies the resistance of a circuit in ohms.

From the foregoing equation it is obvious that, knowing two of the quantities, C, E, or R, it is easily possible to obtain the third, for if

$$C = \frac{E}{R} \text{ then } R = \frac{E}{C} \text{ and } E = C \times R.$$

THE WATT is the unit of electrical energy or power, and is used to measure the rate of the amount of work accomplished by an electric current—*i.e.*, its horse-power (H.P.). The term "kilowatt" is frequently used, and means 1,000 watts. A watt is 1-746 of a horse-power. The number of watts is numerically equal to the product of the amperes by the volts. Hence 1 volt times 1 ampere equals 1 watt, or $\frac{1}{746}$ H.P., and 10 volts at 10 amperes equals 100 watts, which is roughly 1-7th H.P.

Having once grasped the significance of these units, it will not be a difficult matter to apply them in working out calculations. To determine the number of amperes flowing, find out the voltage and number of ohms resistance, and divide the volts by the ohms. If you know the voltage and the number of amperes flowing, and divide the volts by the amperes, the result will give the amount of ohms resistance. Again, knowing the number of amperes and the ohms resistance, the voltage can be found by multiplying the amperes by the ohms. To find the watts being consumed, multiply the voltage by the number of amperes flowing.

For measuring the amount of current flowing in the circuit an ampere-meter or ammeter is used. The ammeter is made or sold by most of the firms supplying bioscope requisites, and may be obtained with a dial scale graduated for various ranges of current.

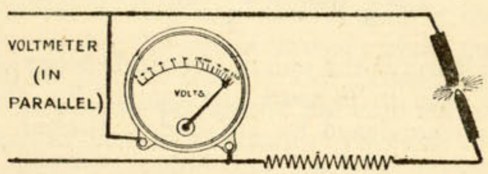


FIG. 1.

For measuring the amount of pressure a voltmeter is used. There are a large number of forms of both voltmeters and ammeters, but generally the principle underlying their action is the same, the difference

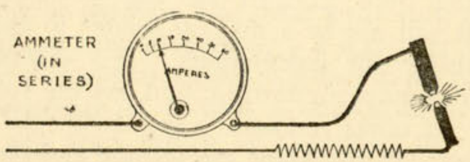


FIG. 2.

being in their application; a voltmeter is connected right across the mains in parallel, as shown in Fig. 1, and has a big constant resistance, so that any current flowing through it is minute, and what current does

flow is proportional to the actual pressure of supply. The ammeter, on the other hand, is placed in the circuit in series, as shown in Fig. 2, so that all the current used passes through the instrument, hence its resistance has to be low.

UNITS. In making their charges, the electrical supply companies do not use the above terms, but charge their customers according to the *work* done for them—that is to say, they do not use the unit of pressure (volt) or of current (ampere) or power (watt), but the unit of work, which is called a Board of Trade unit. Its value is shown us follows:—

1 B.O.T. unit equals 1,000 watt-hours.

1 B.O.T. unit equals 1,000 volt-ampere hours.

(This is equivalent to 10 amperes at 100 volts flowing for one hour.).

Therefore we must consider that the B.O.T. unit is not a unit of electricity, but a definite piece of work done electrically. A practical example will perhaps make this clear:—

On a 120 volt circuit a 16 candle-power lamp requires a current of say 0.5 amperes. Power required is 120 x .5 = 60 volt-amperes = 60 watts. In burning 10 hours, it will therefore require 60 x 10 = 600 watt-hours of work, or six-tenths of a B.O.T. unit.

To ascertain the cost of electric light consumed, multiply the voltage of supply by the amperes taken by the lamp, and also by the time, in hours, that the lamp is burning, and then divide by 1,000; the result will give the number of units consumed in that time. For instance, if 50 amperes are consumed on a 100 volt circuit for a period of 30 hours per week, the total number of B.O.T. units consumed will be

$$50 \times 100 \times 30 \div 1000 = 150$$

With current at 3d. per unit the cost will thus be £1 17s. 6d. per week of 30 hours.

In wiring up from the meter mains it is very important to see that the insulation of the wires is perfect throughout, for faulty insulation is like a leaky gas or water pipe, and means an absolute waste of current. Remember that steam and electricity, when under pressure, are very much alike in their behaviour, for both are constant in their endeavour to escape, the steam into the air, the electricity into the earth; and both on making their escape lose their pressure. As with steam compression, the higher the pressure the stronger must be the plates and rivets of the boiler; so with electricity, the higher the voltage the more perfect must be the insulation. Be careful never to permit wires through which currents of opposite polarity are passing to come into contact, or a "short circuit" may result. A projection arc lamp forms a short circuit when the carbons are closed, and therefore although the short is controlled by the resistance which is placed in series with the lamp, the instant the arc has been "struck" the carbons should again be separated. A true "short" takes place when the two wires of the circuit become joined through direct contact, or by some conductor such as the head of a screw-driver, or through insufficient resistance between the arc and the main, and the result is the instant melting or "blowing" of the fuse wire. The bioscope operator

should always make sure by personal inspection that the safety fuse in the circuit is amply large enough to carry the amount of current that he is likely to require, and that it is placed on the lantern circuit only, so that the hall lights are not dependent upon it. He should always be sure that he has at hand a supply of fuse wire of suitable gauge, so that he can instantly replace a fuse on his switchboard if by any chance it should fail at the critical moment. The operator would be well advised to keep by him a supply of fuse wire which will carry, say, 10 amperes, and he will put in a varied number of strands to carry his current—that is to say, supposing 40 amperes are being consumed by his arc lamp, he will use about four strands of 10 ampere wire for each fuse connection.

Let us suppose we are about to fit up for an exhibition. We find that the electricity is supplied at a pressure of 100 volts, which is now a very general pressure, and we decide that 10 amperes will give us all the light we shall require. We next have to find out the amount of resistance: 10 into 100 goes 10 times, therefore 10 ohms is the total resistance required. The resistance of the arc consuming 10 amperes will be about 3 ohms roughly speaking, and as the total resistance required on the 100 volt circuit to give us a current of 10 amperes is 10 ohms, there will remain something like 7 ohms to be taken up by the rheostat. We will suppose the hall-keeper has been informed of the amperage we propose using, and he has put up the necessary "leads." It is advisable that the leads from the supply company's meter should be connected first with a wall-plug or switchboard, containing a safety fuse in a porcelain mount, as well as two terminals, and from the two terminals of this switchboard the best insulated flexible wires, capable of carrying 20 to 30 amperes with ease, should be connected up with the rheostat and ammeter in the following manner. One of the wires coming from the switchboard is joined up to one of the terminals of the rheostat, and connection made

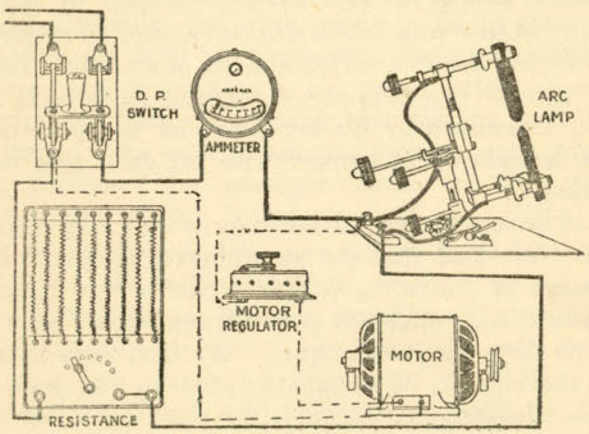


FIG. 3.

between the other terminal of the rheostat, and one terminal of the arc lamp, by means of another piece of flexible wire. The other wire should be attached to the ammeter and the connection made between the second terminal of the ammeter and the arc lamp. The reason for wiring up in this way is, in the one case for the rheostat to give sufficient resistance to control the current, and in the other for the ammeter

to record the flow of the current. Care must be taken when direct current is being used that the positive lead or wire is connected to the upper carbon, which is the larger one, of the lamp, and the negative lead to the lower or smaller carbon. This rule does not apply to alternating current, where both carbons alternately become positive and negative. A reference to Fig. 3. will show the method of wiring up between the main and the arc lamp. When an electric motor is used to drive the projector it should be connected up as shown by the dotted lines in the illustration.

TO FIND WHICH IS THE POSITIVE AND WHICH THE NEGATIVE LEAD. When the operator is not quite certain as to which of the "leads" is positive and which negative, a small piece of electrical apparatus called a "pole tester" will settle the question. Supposing, however, that the operator has not a pole tester at his command, he can find out which is the positive lead and which the negative in the following way: connect up as already described, having previously placed the larger cored carbon in the upper carbon-holder of the lamp, and a smaller solid carbon in the lower holder. Remember that in using direct current the top or positive carbon is always cored and should have the larger cross-section, while the lower negative carbon is solid. For alternating current both top and bottom carbons are cored and are the same diameter. Having connected up, strike the arc by bringing the carbons together and instantly slightly parting them, and allow the lamp to burn for two or three minutes; then switch off the current and watch carefully which of the carbons remains hot for the longer time. If it is the upper one all is well, for that is the positive; if, however, it is the bottom carbon that glows the longer, the leads must be reversed so as to make it the negative.

The sizes of the carbons required vary according to the current wanted, and a table showing the standard size carbons that are required for different currents will be found in the appendix, as also will a table showing the carrying capacities of those sizes of

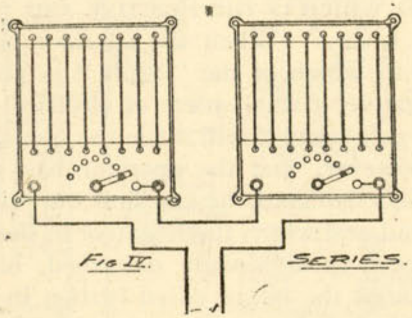


FIG. IV. SERIES.

wires and cables that are in most general use.

THE RHEOSTAT OR RESISTANCE as used by the bioscope operator consists of an insulated metal frame carrying a slate bed, to which is attached, by lugs mounted on the slate, a series of spiral wires that are connected with contact studs by strips of copper. The movement of the hand-lever for contact studs varies the length of wire through which the current has to pass on its way to the lamp, and

therefore adjusts the voltage and intensity of the light. These spiral wires are fixed side by side (with ends joined together), and in this arrangement are said to be parallel; the effect being that the current divides among them. The greater the amount of resistance used the lower the current, and *vice versâ.* Where the voltage is very high—*i.e.*, from 200 to 250 volts—two or more rheostats are used, being so connected that their wires are added together end to end, when they are said to be in series with each other,

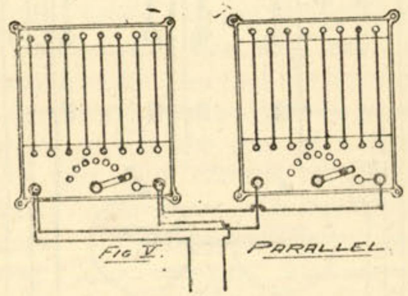


FIG. V. PARALLEL.

and their resistances are added together; if on the other hand a heavy current is to be used the rheostats are connected in *parallel.* Figs. 4 and 5 illustrate the series and parallel methods of connecting up resistances.

It must be borne in mind, however, that the use of resistances for breaking down voltages from, say, 250 to 60 or 65, is an extremely wasteful procedure, and in all except purely temporary shows some form of rotary machine is nowadays almost invariably used. At the same time it must not be forgotten that there is always a possibility of a "fault" developing

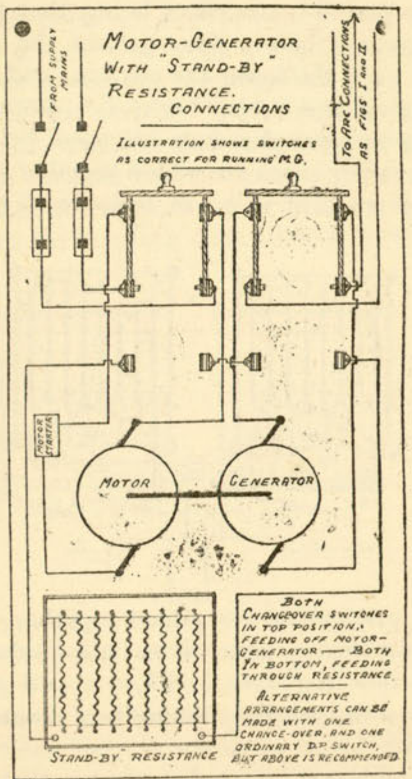


PLATE IV.

FIG. 6.

in a rotary machine and it is always advisable to keep a "stand-by" resistance on hand ready for im-

mediate use in case of emergency. Fig 6 (which is one of many useful diagrams that are contained in the Bioscope Electrician's Handbook) illustrates the method of wiring up for such a resistance. It will be seen that the change-over from motor-generator to resistance frame can be made almost instantaneously.

In view of the fact that the use of resistances is an extremely wasteful method of breaking down the voltage in a cinematograph arc lamp circuit, it may be taken as an axiom that one or other of the various types of transformers or converters should *always* be installed if the supply voltage is higher than 100.

These "rent-payers," as they have often been termed, because of the fact that the amount of money saved on the electric light account is generally more than sufficient to pay the rent of a hall, may be divided into four main classes, viz., Motor Generators, Rotary Converters, Auto-Converters, and Transformers. Inasmuch, however, as the latter give-in and also take-out alternating current only, they are very seldom utilised in the projection arc circuit, but in conjunction with low voltage metallic filament lamps there is no more economical method of lighting a building.

A TRANSFORMER consists essentially of two coils of wire wound separately around some soft iron, one coil of which is connected across the electrical supply mains and is called the primary, while the second one is connected across the house circuit and is called the secondary.

Its action is due, first, to the fact that when a current of electricity flows around a bar of iron, it converts the iron into a magnet; secondly, when the magnetism in the iron changes, it induces a difference of electrical pressure across the two ends of the coil of wire wound around it, which difference of pressure is proportional to the number of turns of wire in that coil, so that if one coil has only a quarter the number of turns of the other one, its difference of pressure will be only a quarter of the other one. In the primary—*i.e.*, the coil connected to the mains—this induced pressure opposes that due to the supply and is rather less than it, and the difference of these two pressures determines the amount of current flowing through the coil.

The change of magnetism is caused by the flow of the current alternating in direction, as has already been explained, so if there are no alternations, as in the case of direct current, there will be no induced pressures, and the transformer will be useless. It is important to note that when using a transformer in circuit with an arc lamp, a small resistance must be inserted in series between the transformer and the lamp so as to steady the light and make it burn better, but even then the results obtained are distinctly inferior to those which emanate from an arc that is connected to a direct current circuit.

A type of transformer that is becoming increasingly popular is known as the Auto-transformer, and it differs from the ordinary transformer in the fact that the primary and secondary coils are electrically continuous instead of being separate and distinct. The Auto-transformer has a slightly higher efficiency

than the ordinary type, but otherwise it possesses no greater advantages for projection work.

Whilst discussing transformers, it may not be out of place to give a hint to those who decry transformers for ordinary lighting with metallic filament lamp because of what are termed " no-load " losses. These are due to the fact that a slight magnetic leakage from the iron core is constantly taking place, but if the switches on the primary (*i.e.* the main) side are kept open during the time that the current is not required, no such leakages can possibly occur. It would, of course, be extremely inconvenient in a private house to have to close the main switches every time it was desired to switch on a light, but in a picture theatre where the light is only required at definite periods of the day, no such objection could possibly prevail.

CHOKING COILS. A choking coil is similar in action to a transformer, but there is only one coil of wire which is connected in series with the arc lamp, and there is less iron used in the instrument.

The choking coil is more handy for a bioscope operator, but the variation which can be obtained is very much smaller than with a transformer.

MOTOR GENERATORS. Undoubtedly the best machine for use in cinematograph theatres which are supplied with alternating current is the motor generator. By means of this machine a high voltage *alternating* current can be transformed to low voltage *continuous* at less than half the cost per hour than if an ordinary line resistance were used.

As its name implies it consists of a motor and a generator (*i.e.* dynamo) coupled together through their shafts so that the two armatures revolve at the same time and at the same speed, but without having any electrical connection one with the other. The motor generator will also transform a high voltage continuous current to a low voltage of the same genii and *vice versâ*, but the most efficient machine for that purpose is the Rotary Converter.

ROTARY CONVERTERS. The rotary converter is really a modification of the motor generator, the main difference being that the two machines of the latter are combined in one. The field coils are common to the motor and the generator, and the armature (which is sometimes divided into two parts) has a commutator at either end. Partly owing to its high efficiency and partly to the fact that the expense and trouble of maintenance is reduced to a minimum because of its fewer number of wearing parts, the rotary converter is rapidly ousting the motor generator from the high position which it once held. Another argument in favour of the rotary converter is that the amount of space it ocupies is much less than is required for a motor generator.

There is one other type of voltage reducer that is worthy of mention in this book, and that is the AUTO-CONVERTER. In this machine there is only one commutator, which serves the double purpose of receiving the high voltage current from the mains and of giving off the required low voltage on the secondary side, and in view of its marvellously high efficiency

it is rather surprising that it has not attained a greater measure of popularity.

Although the question of the comparative cost of the electrical energy consumed by various types of voltage reducers is not, strictly speaking, part and parcel of the profession of bioscope operating, we believe that all will agree that the subject is of sufficient importance to merit a mention of it in this book.

It is an unfortunate fact, but is nevertheless true, that a very large number of embryonic picture theatre proprietors cannot or will not realise that an expenditure of £60 or £70 in the purchase of a rotary machine, will be more than repaid in a very few months by the reduced current bill which will be the natural corrolary of the introduction of such a machine.

For the sake of argument let us suppose that the efficiency of a motor generator is 70 per cent., of a rotary converter 80 per cent., and of an auto-transformer 90 per cent. These figures are necessarily approximate because of the variation in the designs of different makes of machine, but they are substantially correct and quite sufficient for the purpose in view.

Assuming that 50 amperes at 65 volts pressure are required for periods which total fifty hours per week and that the supply voltage is 250, charged for at the rate of 3d. per unit the cost, using an ordinary resistance, will be

$$50 \times 50 \times 250 \times 3 \div 1000$$

which equals 1,875 pence, or £7 16s. 3d.

If a motor generator is used to transform the current from 250 volts to 65 volts for the similar number of hours, the cost will be

50 x 65 x 50 x 3 ÷ 1000

i.e. 487 pence, but seeing that we are assuming the efficiency of a motor generator to be 70 per cent. the difference between that percentage, and 100 per cent. must be added. The total cost is therefore

487 x 100 ÷ 70

which equals 696 pence, or £2 18s. It will thus be seen that by using a motor generator in preference to a resistance, a saving is effected of no less than £4 18s. 3d. per week, which is sufficient to repay the capital outlay in about sixteeen weeks!

In the case of rotary converters and auto-converters the difference is even more marked, for with efficiencies of 80 per cent. and 90 per cent. respectively, the costs work out at £2 10s. 9d. and £2 5s. 1d., and the saving to £5 5s. 6d. and £5 11s. 2d. per week.

In many of the English provincial towns the charges for electric light are so high, and the authorities so despotic, that it is no wonder many showmen are installing small petrol-driven generating sets in their picture theatres, and thus making themselves independent of outside sources of supply.

These petrol sets are also extensively used by travelling showmen, particularly in the Colonies, and they have almost completely ousted limelight as an illuminant in tent and similar shows.

The operator therefore would be well advised to make himself acquainted with at least a few of the salient points to be observed in the selection and

maintenance of the apparatus that is necessary for the purpose of generating electricity independent of outside sources of supply.

A reliable combined paraffin, or petrol, electric generating set, giving an output of 3,000 watts, may be purchased for about £100, smaller ones ranging from £45 upwards. The machines are made so compactly that they can be stowed into any odd corner, although, of course, they should be placed where they are easily accessible for cleaning, adjustment and repairs. As to the latter, the design and manufacture of these generators has been brought to such a high standard of perfection that with fair usage they will run for years at practically no expense for replacements.

Any fairly intelligent operator (preferably one who is not *too* handy with a spanner) will encounter very few difficulties which he cannot solve without calling in expert aid, and if he is already a motor cyclist, he will have fought more than half the battle. With these small paraffin or petrol generating sets, any stoppage can usually be traced to the engine, and as it is practically only a motor cycle engine mounted on a base plate, the trouble is easily located and rectified. The dynamos seldom give any trouble, provided that the commutator is kept clean and the bearings well oiled.

When the installation of a generating set is being considered, the first question that arises is the winding of the dynamo, and of the three standard windings—series, shunt, and compound—it will generally be found that a compound-wound machine will give the best results for picture theatre work. The great advantage of this type of winding is that the voltage remains constant no matter what amount of current is being consumed, and although the switchboard necessary for this type of machine is rather more complicated than it would be for either series or shunt-wound machines, the difference is more than compensated by the greater efficiency obtained. One great advantage is that there is no fluctuation in the brilliancy of the remainder of the lights in the hall when the projector arc is switched on or off.

The semi-enclosed type of dynamo will be found the most useful for the purpose, although it may be what is known as "open-type" if the room in which it is placed is very small and stuffy, so as to allow free access of as much fresh air as possible.

These two principal features—*i.e.*, the type of enclosure and the windings—are the main points to be considered in reference to the dynamo; any manufacturer who has any sort of reputation at all to lose will take care that the machine will generate the stipulated output. The shaft of the dynamo should be directly connected with that of the engine by means of a flexible coupling, because belting is not only noisy, but it tends to shorten the life of the machine, owing to the wear on the bearings. The position of the fly-wheel is really immaterial, although it is usually placed on the shaft between the engine and the dynamo, and in this position it is certainly out of the way of passers-by, and in addition the strain upon the bearings is more evenly balanced.

The principal features of the engine to which attention must be devoted are the ignition, the governor, the vaporiser or carburettor, and the system of lubrication. The high-tension magneto is the ideal ignition, but the first cost is greater than an accumulator and coil; nevertheless, the few pounds so spent will be money well invested. Lubrication—splash system or rings—either are good; the vaporiser must give perfect combustion at all loads, and the exhaust should be flexible an odourless. The governor, particularly when the dynamo is compound-wound, must be sensitive and reliable, and it is imperative that the cylinder should be surrounded by a water jacket of ample size, so that the cooling water may circulate freely.

Thus briefly have been enumerated the principal points to which the buyer of a generating set must give time and consideration, and if machines with a reasonable efficiency are obtained, the cost of current, even after allowance is made for depreciation of plant, will not exceed 2d. per unit.

In connection with these small generating sets it should be mentioned that if it is intended to use metallic filament lamps, these should on no account be lighted direct from the dynamo. These lamps are very fragile, and being extremely susceptible to variations of voltage they should always be run off a set of accumulators, and although the extra cost of such a battery is rather high in the first place, any sum so spent will be more than saved by the longer life obtained from the lamps. In addition there will be an entire absence of flicker, which is to a certain extent unavoidable when the lamps are in direct circuit with the dynamo. Another advantage of using accumulators is that they can be charged up during the daytime, and thus any breakdown in the generating set at night will not throw the whole place into darkness. It need hardly be said that no attempt should be made to run the projector arc from the battery. Such a course would be disastrous to the accumulators.

It is essential that the bioscope operator who aspires to reach the front rank of his profession should be thoroughly capable of maintaining a generating plant in perfect condition, and the more competent he is in that respect, the greater will be his chances of success.

The operator must never forget the fact that the very life of the show depends absolutely upon the quality of the picture that is projected upon the screen. A badly projected picture spells ruin, and so does a failure of the electric supply. He must therefore at all times concentrate his attention upon the quality of the light which is produced at the arc.

Now it stands to reason that in order to obtain the best possible light in the lantern, the generating machine must be cared for just as if it were one of the most delicate pieces of clockwork that was ever made.

Let it be clearly understood, however, that the man who is eternally using a spanner on an electric generator is probably doing it more harm than good, There must be a happy medium in these things; if not—well the machine will soon ventilate its

grievances by coming to a standstill at the most inopportune moment.

The most frequently recurring troubles that confront the man who is in charge of a motor or dynamo are those relating to the commutator, upon the smooth-running of which the steadiness of the output depends.

Every morning the machine should be started up, and careful examination should be made in order to ascertain whether the brushes are correctly adjusted. The latter must not be allowed to press too hard upon the commutator, otherwise they will wear away very quickly, and the commutator will become badly scored. Care must also be taken that the brushes are set in the position in which the least sparking takes place.

With some machines it will be found that the commutator persistently becomes scored. In that case it is a good plan to "stagger" the brushes; that is to throw them out of line into a series of steps so that the rows of brushes have a slightly different bearing surface on the commutator. By that means the trouble is prevented and the wear takes place evenly over the whole surface.

Do not fall into the common error of increasing the tension of the brushes on the commutator if sparking is observed but make quite certain that the brushes are correctly adjusted and trimmed. If, after that, the sparking continues the cause must be looked for elsewhere.

Blackening of the commutator is due to the making and breaking of contact by the brushes, and this is caused by vibration. It is of extreme importance that vibration should be reduced to a minimum, and inspection should be periodically made to see that all bearings are properly adjusted, and that the foundation bolts have not worked loose.

The trueing up of the commutator is an operation that requires very careful handling, for it is quite possible for an inexperienced man to do more harm than good to the machine.

The common practice of endeavouring to grind

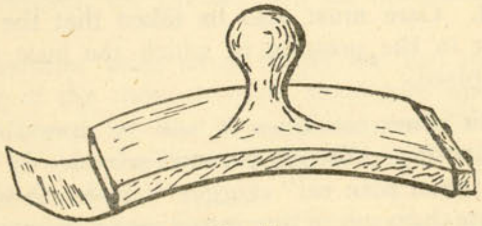


FIG. 7.

down a commutator by means of a flat board and a piece of emery cloth cannot be too strongly condemned because of the fact that it tends to aggravate the irregularities.

The correct board for the purpose should be made of a block of wood hollowed on the inside, of but slightly larger radius than the commutator. With such a board, which can be obtained direct from the makers of any machine, or might be cut by a carpenter in a very little time, the commutator can be nicely trued up and any small irregularities, high or low, can be removed.

Fig. 7 illustrates this type of board, which is fitted with a small screwed clamp at one end to grip the grinding cloth. If this be used, the free end of the cloth must, of course, be pointing in the direction of the rotation of the machine. Carburundum or the finest glass paper should be used for grinding down commutators. Emery cloth *never*. After grinding down the commutator, great care should be taken to see that no particles of metal remain between the segments.

After carrying out any work on the commutator the brushes should be carefully bedded-in. There are two ways of doing this—a right and a wrong.

Fine glass paper only should be used for this purpose, and the brush should not be removed from the holder. The brush arm is generally fitted with two or more holders for the brushes. All but one brush should be lifted, and a strip of glass paper wider than the brush inserted between the latter and the commutator. The paper should be drawn from side to side, always bearing in mind to keep it well down on the commutator for some distance on either side of the brush. It will not suffice to draw the paper to and fro under the brush, as in that case a more or less flat surface will be obtained, whereas the bearing face of the brush should partake of the same curvature as the commutator itself.

Fig. 8 illustrates the method of bedding-in the brushes, and the cloth should be drawn alternately from side to side in the direction of the arrows. The procedure is very simple, but it must be carefully carried out or bad commutation will be the result.

After bedding-in the brushes and facing up the commutator, a considerable amount of carbon and copper dust will have found their way into the brush

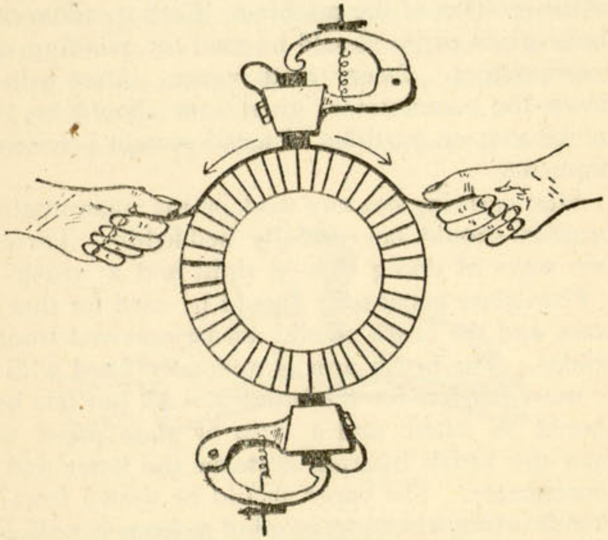


FIG. 8.

holders and the armature itself. If the brushes be removed, any accumulation can be blown out with hand bellows, which always form part of a dynamo attendant's kit. With these it will also be possible to remove any accumulation from the interior of the armature windings. Indeed, it is advisable that a

practice should be made of occasionally blowing out the whole machine to rid it of the tremendous amount of dust that is picked up whilst running.

Every attention should be paid to the commutator. It should always be kept clean and smoooth, but oil or vaseline must *not* be applied to the commutator of any machine that has carbon brushes. Machines which have copper brushes may have the merest trace of vaseline applied to the commutator daily whilst it is running.

An elementary point, but not by any means the least important in the running of dynamos and motors, is the attention required to the bearings.

In most modern machines the bearings are fitted with oil-wells, with rings running on the motor shaft for lubricating purposes, and it is most essential before starting the machine to note the level of the oil in the well. Should the bearing be fitted with an oil gauge, the height of the oil can be readily ascertained at sight. Too much reliance, however, should not be placed upon the gauge, without occasionally checking the level of the oil in the well. The top of the oil gauge, which consists of a glass tube in a brass mount, is usualy fitted with a cap of that metal, a small hole being drilled in the top. This, of course, is to permit the free entrance and exit of air with the rise and fall of the coil. It frequently happens, especially after cleaning and polishing the machine, that a certain amount of cleaning paste, or other foreign matter, becomes lodged in this hole. The result is that an airlock is formed, and consequently the oil maintains a stationary position in the gauge, and so shows a false level of oil in the bearing.

The level of the oil in the well of the bearings should be such that the rings, which do the lubricating and convey by their rotating motion the oil from the well to the shaft, dip sufficiently in the oil to gather it up when the ring is in motion. The oil should never be permitted to drop lower than a little above the inside circumference of the ring, and it is equally important that it should never be attempted to fill the oil-well to such a height as to touch the shaft, as in that case the oil will overflow and possibly creep along the shaft until clear of the bearings, when it will be thrown by centrifugal force on to the commutator, armature, and field-coils, where, by its action upon the insulation, considerable damage may be done.

If there be insufficient oil in the bearing, more should be added, and the finest mineral oil of good body bought from reputable firms only, should be used for this purpose. Only the better class of those kinds known as dynamo oils should be selected. It is very false economy to use poor oil, as very little is required, and on an increase of temperature such oils speedily lose their lubricating properties, with disastrous results to both the bearings and the shaft.

Fig. 9 illustrates the principle of the bearing now in almost universal use, the oil being very economically used, as it is conducted to the shaft by the rotating ring, and after going through the bearings returns again to the well. Immediately after starting up it is of prime importance that the bearing cap should be lifted to see if the oil ring is revolving.

It frequently happens that the ring is sluggish in this respect, this being particularly the case in cold weather, when the oil is thicker than normal. Should the ring not be revolving, it may be started by inserting, say, the end of a lead pencil and pushing the ring round in the direction of the rotation of the shaft. This examination of the oil ring should invariably be done, as it must be clearly understood that if the

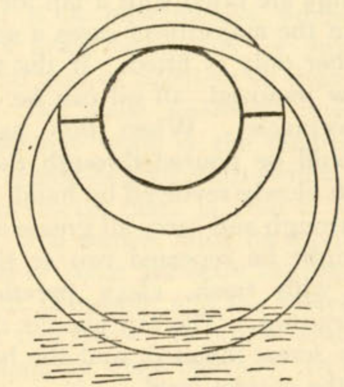


Fig 9.

ring fails to work, the lubrication quite ceases, and within a very short time the excessive heating will cause seizure of the shaft to the bearing.

Although the oil in the bearing is practically everlasting, and only occasionally requires a small addition, it must not be assumed that its lubricating properties remain undiminished; on the contrary, dust and dirt, which are sure in some way or another to find their way into the bearing and mix with the oil, will cause considerable scoring of the bearing and shaft unless the oil be occasionally run off and a complete fresh supply put in.

In a room comparatively free from quantities of dust, and of not too high a temperature, it is advisable to renew the oil about every six months, and at the same time thoroughly clean out the oil wells. Some bearings are fitted with a tap for draining purposes, but in the majority of cases a set screw with a leather washer only is fitted. If the tap be opened or the screw removed, all oil can be trained into a suitable receptacle. When this has been done paraffin should be poured through the bearing cap and the shaft slowly revolved by hand. The paraffin will drain through and carry all grease and dirt before it. This might be repeated two or three times, in every case with fresh, clean paraffin, to ensure thorough cleaning. The tap should then be closed or the drain screw inserted, and the bearing refilled with oil to the correct level.

It is sometimes advisable, after such clearing, to first fill the bearings or pour over the shaft some thick castor oil, and run the machine for a few minutes with this. This will clear out the paraffin—which, it must be remembered, has no lubricating properties whatsoever—and prevent all danger of seizure owing to insufficient lubrication of the shaft. If this be done, this oil should then be run off and the bearing filled with the usual oil before the machine is started

on load. Whilst on the subject of lubrication it may be remarked that it is advisable to use only oil feeders non-attractive to magnetism, that is, those in which no iron forms a part of their construction. Many serious accidents have been caused in the past by the careless use of an iron feeder, which has been attracted by the dynamo magnets into the machine. With most modern machines the field magnets are designed so that there are very few stray magnetic lines, there being, therefore, not so much danger of an accident occurring. but it is, nevertheless, advisable to use only copper or brass oil feeders for any work near dynamos, as all risk of accident is thus obviated.

SWITCHES. The most universal type of switch used for projection work is the double pole knife switch. The button-headed snap-switch, enclosed in a dome-shaped metal case, is also a form of this knife-switch. The switch must be mounted upon a base composed of some perfectly insulating material such as slate or porcelain, and the switch itself must be well-made, free from "wobble," and must strike the contacts squarely when closing. In fastening up your switch make it a fixed rule that it is so mounted that the switch handle will hang downwards when the switch is open. This is of very great importance, as it makes it absolutely impossible for the switch to accidentally fall into place and so cause serious damage. The live wires or leads, coming from the mains, are attached to the terminals marked 1 and 2 in Fig. 7 and constitute the live ends of the switch; 3 and 4 are the terminals for the wires from the switch to the resistance and the ammeter, and this is called the "dead" end—*i.e.*, it is not charged when the switch is open. Remember that the fuse end of the switch, where the fuse-wire is attached, *must always be at the dead end of the switch.* The fuse-wires are attached to the binding posts marked *aa* and *bb*; *cc* are the switch contacts, and *dd* the

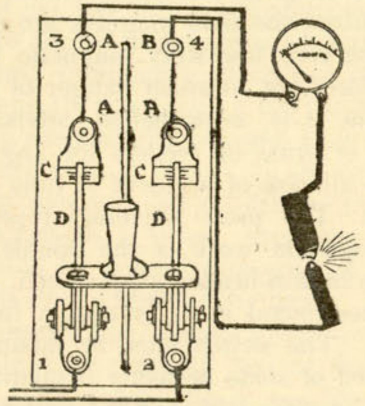


FIG. 10.

knife contacts, which should always be kept tight to prevent undue heating. It is important to keep the contacts smooth and clean, as they are apt to become roughened when a strong current is used, by arcing when the switch is opened. Never attempt to clean the contacts until you have made sure that they are disconnected from the mains *i.e.*, main leads disconnected, or house-switch controlling circuit to your switch, thrown out—then you may safely clean them with the aid of a very fine file. Always open the

switch with a quick sharp jerk, so as to reduce the arcing between the contacts.

WATER RESISTANCE. It often happens that when an operator is in some out-of-the-way spot, his resistance is rendered useless, or lost, and in that event he must utilise his common-sense and ingenuity in devising a make-shift.

With a little time to spare he need not give up hope. In the first place two plates are required—but they must be metal. Any metal will do, copper, of course, being best, but if this is not available, as a last resource tear open a saucepan and use the sides. It is not generally difficult to get these soldered in such conditions, but if not they can be bolted, many means being available for securing a small bolt.

Then get a tub—one of those with "ears," if possible, failing which obtain a barrel from the local public-house. Then obtain two sticks—broomsticks suit the purpose admirably—and attach these to the plates and the apparatus is almost ready.

The leads should be tied round to prevent them from shifting, and on no account must the plates be allowed to touch one another. To prevent this, bricks, pieces of wood, or other non-conducting substance, should be placed between the two.

The apparatus should not be too small, otherwise the water will quickly boil, and evaporate away.

Salt water conducts electricity better than fresh water, and it is best to start with fresh water and add salt gradually as required. Sulphuric acid is used for reducing the resistance, but this would most probably not be obtainable in the circumstances, and the next best thing to use is vinegar.

This apparatus can be placed in circuit in the same way as the ordinary wire resistance, and will give very passable results.

CHAPTER IX.

THE CARE AND ADJUSTMENT OF THE APPARATUS.

1. *Care of Projector*—2. *Importance of Cleanliness*—3. *Starting a New Machine*—4. *Care of the Gate*—5. *Function of the Gate*—6. *Strength of the Gate Springs*—7. *Wear of same*—8. *The Take-up Mechanism* — 9. *Adjustment of Friction*—10. *Spools*—11. *Automatic Cut-off*—12. *Improvements of same*—13. *Hand Cut-off*—14. *The Intermittent Mechanism*—15. *The Beating Roller*—16. *Care of the Maltese Cross*—17. *Pin and Claw Movements*—18. *Lubrication*—19. *Setting the Shutter*

WHEN moving pictures first became recognised as a form of entertainment, a deal of mystery surrounded the machinery with which they were produced. Projectors were carefully guarded from view, so that no layman should know the means employed, and the operators of the diverse styles of apparatus were careful that no competitor should find out the special form of appliance in use. Projectors were carefully packed and locked up, or even taken home after each performance. They were kept clean and guarded from injury, and the secrets or supposed secrets of their mechanisms, and the names of their makers carefully preserved. Later, the number of operators and mechanics became so great that the mysterious side of the question faded away, and the operators, instead of taking special pride in their apparatus, began to look round in order to find a practical machine not liable to derangement, and one that could be quickly set up for work and as quickly packed up after the show was finished. The position of the operator became a less lucrative one, the machines were more easily worked and kept in order, and as less special knowledge and care were needed, familiarity produced its usual offspring, contempt, and careless workers were not conspicuous by reason of their rarity. During the last year or two the pendulum, having reached the end of its swing, has started on its return journey, and from day to day an improvement in the style of operators and operating is becoming increasingly evident. The public is becoming more critical, competition more keen, and to satisfy the public taste and keep in the front rank it is now not only necessary to provide good machinery and films, but also to place them in the hands of competent and painstaking operators.

Good apparatus, good films, good surroundings, may be provided, but unless the operator be also good the performance will, even if good at the start, soon degenerate into a second-rate one. It may be a matter of days or weeks, according to the interest taken in the machinery and its consequent treatment.

A projector, good in the first place, will, with reasonably careful usage, last a long time without showing much falling off in the excellence of its results, while if neglected the pictures it produces will soon become unsteady. Cleanliness of the gate will prevent wear of the films, and regular cleaning and oiling of the machine will allow the spindles and bearings to retain their good fitting qualities for a long time. A new machine seldom runs quite as well as one that has had a little use. The spindles and bearings, the teeth of the gearwheels, and fittings of all kinds, are always somewhat harsh when leaving the workshop compared with their condition after some running, and when the different parts by a small amount of wear have become properly "bedded" to one another. This harshness must not be ascribed to defects of manufacture, because even the finest productions of engineering science, for instance, the engines of an ocean steamer, are always expected to work more sweetly after a few trips have been made with them.

VASELINE FOR THE GATE.—Vaseline is often used on the gate and springs after cleaning, and is very good if not too lavishly put on, only a small quantity being needed. However small an amount is applied, it is advisable to lightly rub it off with a fairly clean rag—enough will still remain for the purpose required.

STARTING A NEW MACHINE.—Much good may be done to a new projector by being careful to oil it thoroughly before each time of using, and by wiping all black or dirty oil away after the performance is over. This should be continued until the oil runs from the bearings almost clean, and when this is the case the machine will probably be in the best condition it will ever experience. All dirt and grit left from the manufacture will have been washed out, and the spindles and working parts will have worn off the minute irregularities which had been unavoidably left by the tools of the maker, and the fittings of all the parts will not have become loose by the grinding which would have taken place had not the dirty oil containing the particles of metal and grit been carefully wiped off.

CARE OF THE GATE.—The gate, also, should have special attention when starting a new machine. Although beautifully smooth and polished, it is probable that the first few performances will reveal parts of the pressure surfaces which stand somewhat above their best position. Only the wearer can tell where the shoe pinches, and only the film can tell where the pressure is hardest. This is the position where dust, dirt, and the rubbings from the film will accumulate, and if allowed to, the film will naturally suffer; but, beyond this, the gate of the machine will suffer also, because the accumulation will protect the high part and it will become still higher in proportion owing to the wear of the other unprotected parts. If with a new gate extra care in cleaning be taken, it will rapidly settle down and give little or no trouble, because the pressure surfaces will soon be as level and smooth as the film can make them. Many operators use a penny or other coin to scrape adhering matter from the gate. No doubt this is very convenient, because coins are easily at hand. A better tool for

the purpose can be made by cutting a piece of hard sheet brass, about 7 in. long, to the width of the gate, and carefully squaring and smoothing the end. If truly made a single sweep of this along the gate will clean the surface, edges and corners much more completely than can be done by twenty or thirty rubs with the edge of a coin, the round edge of which will not deal at all well with the corners.

The gate must not only be kept clean and smooth, but special attention must be given to see that it is also in its proper adjustment. Among the newer styles of projectors are some fitted with gates differing considerably from the old general form—*i.e.*, the one containing the spring-plate (usually interchangeable) with its six springs; and the opposing guides with the hump or projection on each. The original idea of the "hump" was to cause the film to bend just before and just after the "masking" position, so that the film might lie flat whilst being in the path of the light rays, without being touched by any part of the machine except just at the edges. If a piece of film be bent in one direction it cannot easily be also bent in a direction at right-angles to the first position at the same time. The old makes of films showed a great tendency to set in a curve, hollow towards the gelatine side, and it was for the purpose of overcoming this tendency that the hump was introduced. In order to focus the centre and the edges of the film at one and the same time, it is necessary that the film should be fairly flat when passing the mask. A slight curvature with its hollow side towards the projecting lens would with most lenses be advantageous, but unfortunately the tendency to curvature is in the other direction when working in front of the screen; and the front position is now the usual one. In the old gates, the springs themselves pressed directly upon the edges of the film; in the new ones the springs hold the film down by pressing on runners, or "skates," which are guided by rods, or studs. Sometimes the springs press directly upon the skates, and sometimes upon the rods which are fixed in the said skates. The skates present long smooth surfaces, which fit accurately on the opposing guides, and by gripping the film at each edge cause it to set flat between the edges, although unsupported in the middle. Velvet, a material much used in the first days, has disappeared from the gates of projectors. Although it gave an almost perfect friction, steady and light when new, it rapidly accumulated dust and dirt, and if not frequently renewed caused the films to scratch and tear up.

FUNCTIONS OF THE GATE.—In order to know how to keep the gate in good condition it is necessary to understand the functions of the gate. It is, first of all, a guide to keep the picture from moving to the right or left during its passage through. Its second function is to flatten the film so that the whole of one picture can be focussed at the same time. Its third and most important object is to put enough drag or friction on the moving film to cause it to come to rest immediately the intermittent mechanism ceases to act. Should the pressure springs be too light, the

film will have a tendency to run a little farther than it has been moved by the mechanism. If the amount of this over-shooting were always precisely the same, no harm would be done by having the pressure springs weak, but unfortunately friction is a force which is not susceptible to exact regulation, and the slightest variation in the thickness of the film, or of its condition as to dryness, will alter the drag of light springs enough to allow the film to run forward by its own impetus at one moment, and to stop promptly the next.

STRENGTH OF GATE SPRINGS.—It is therefore necessary to have these springs sufficiently strong to stop the over-shoot with certainty every time. With the beater or "dog" machine this is all important, because the gate tension is the only factor in bringing the film to rest. With the Maltese Cross and pin movements the mechanism itself operates to stop the film as well as to move it, consequently the gate springs only act in subduing vibration in the film, and in keeping the gears of the machine in contact, and minimising back-lash or shake among the important moving parts constituting the intermittent mechanism. The gate springs must, therefore, be strong enough, but they must on no account be too strong, or damage to the film will be the result. Luckily, owing to the tenacious nature of celluloid, there is a considerable difference of strength between the "too weak" and the "too strong" condition; still, to adjust these springs to a nicety requires careful manipulation. The best way is to start with the springs too weak, when the picture on the screen will have a large amount of faulty registration up and down, and if the gate be a wide one, or the film be narrow, it will also be faulty in the right and left direction. Gradually strengthening the springs will reduce the "jump," and this should be continued, testing the machine from time to time till no further improvement is noted. An attempt should be made to keep all the springs about equally strong when the gate is shut. The gate supplied with "humps" must have its springs opposite to the humps less heavily sprung than the remaining ones, so that the tension on all may be even when the gate is closed.

WEAR OF GATE SPRINGS.—When the machine in use is fitted with a gate, the springs of which press directly on the film, the operator should be alive to the fact that celluloid and gelatine have the power of cutting hard steel at quite an alarming rate, and the springs should be periodically examined to see how far wear has proceeded, and whether the springs, by wearing thin and becoming weak, are allowing the film to over-shoot and spoil the quality of the picture. The springs should be replaced by new ones long before the time when they will wear right through, as should this occur the remaining parts of the spring, being of razor sharpness, may shear about 3-16th in. off the edge of the film, from end to end, ruining the film, and causing great danger of fire, because some of the shearing may come to rest in the gate.

THE TAKE-UP MECHANISM.—Having seen that the gate is in good order, clean, and properly adjusted, the next point that claims attention is the take-up mechanism. Neglect of the condition of this part has been the cause of one or two bad fires, and of the spoiling of large quantities of film. The take-up arrangements always include a friction drive of some sort. In the older models the driving band often acted as the friction drive, but recently there is a tendency to gear definitely together the wheel on the spool-spindle and the machine; either by a shaft having mitre or bevel wheels at each end, or by a pair of chain-wheels and a suitable chain. The device for allowing an increasing amount of slip as the size of the roll on the spool becomes larger is then necessarily quite a separate arrangement. Sometimes a leather washer running between two metal plates, which are pressed together by a spring, is used for supplying the necessary friction; in other makes metal or fibre washers alone are used. Whatever form the friction drive takes it is usually supplied with an adjustment by which the friction may be regulated, and on the proper regulation of this friction the satisfactory working of the take-up mechanism depends. This adjustment is easy to make, provided the proper course is taken, and provided a clear understanding of the exact requirements is in the mind of the operator.

ADJUSTMENT OF TAKE-UP FRICTION.—The limits to be kept within are the following: First, the friction must be strong enough to drive a full spool decidedly and without hesitation. Second, it must not be so strong as to damage the perforations in the film at the beginning of the winding, when the size of the roll of film is very little larger than the core of the spool. When this latter condition obtains, it usually makes itself evident by a clicking noise caused when the perforations leave the teeth of the lower sprocket, but this noise must not be taken as a definite indication that the take-up friction is too heavy.

Uneven or bad gauge in the perforations will cause a very similar sound to be produced, and before slackening the tension, the gauge of the film should be verified. When a machine persistently gives out this noise at starting, it is a fairly certain indication that the take-up friction is too strong, and the spring should be slackened; but the operator should pay special attention to the spool directly it becomes fairly full, to insure that in slackening the spring he has not made the tension too weak to properly drive a full spool. Sometimes, during the filling of a spool, it gets much out of the true balance, due to the core being out of centre, or to some unevenness in the film itself. Such a spool will have a great tendency to stop when nearly full, and if not wtched, may deposit the last 100 ft. on the floor, to the great danger of damage to the film from dirt or by being trodden upon.

LARGE SPOOLS.—When the spools are constructed to take 1,000 ft. of film, and also are provided with reasonably-sized cores, no trouble should be experienced in adjusting the take-up to do its work sufficiently gently when the spool starts, and also to act with certainty with a full spool, even though the spool be somewhat out of balance. With much larger capacities more trouble will be experienced, and greater nicety of adjustment demanded, and attention should be given to see that the spools themselves are quite true, and well balanced, or failure to take up properly will be certain to be encountered from time to time.

CLEANING THE TAKE-UP FRICTION.—Friction alters so much from day to day, due to change of temperature and change of humidity in the atmosphere, that a periodical examination of this part of the projector should be a part of the routine of every operator's duty. An extra amount of oil may make the tension too light, a day's rest may cause the oil to thicken, or if the oil contains free acid (and this is often the case) slight oxidation of the metal friction surfaces may take place, and result in a considerably increased pull on the film, to the detriment of the perforations. Where leather washers are employed, the acids in the leather often attacks the metal surfaces with which they are in contact, and variable or increased friction may result. It is well to take the washers out from time to time and soak them in petrol or benzoline, to remove the oil with which they have become saturated. After drying they can be replaced, and the spring be re-adjusted, and an endeavour should be made to keep oil away from the leather. This is somewhat difficult, owing to the proximity of other parts which *must* be oiled, but a careful operator will find his work much lightened by attention to this point. The certainty of the action of the take-up will remove one more anxiety from the mind of the worker, already burdened by the multifarious requirements necessary to perfect operating.

THE AUTOMATIC CUT-OFF.—The special parts of the projector hitherto treated of in these chapters have been common to all projectors, and although next in importance come certain items concerning the intermittent mechanism, it is best to deal first with such points as are usually present in the machines irrespective of the systems on which they are constructed. The automatic shutter or cut-off has come to be considered an essential part of a complete projector. Whether its utility is great, or whether the County Council was wise in insisting upon its general adoption, will not be discussed here; it is a compulsory adjunct to a projector, and must be dealt with. The automatic cut-off may be said to be the most delicate part of the machine, and is in consequence very liable to derangement. Many forms are in use, all depending upon the principle of the centrifugal governor. Turning the handle of the machine, or otherwise driving it, one of the quick-running spindles, by communicating its motion to a part or parts, arranged to change position by being whirled round, causes a shutter to lift when a certain speed has been attained. When the speed decreases, the parts, being no longer under the influence of sufficient centrifugal force to keep the shutter open, allow it to close. The idea is, that should the machine cease running, the automatic

shutter will cut off the light and heat from the film before the machine comes to rest. Automatic shutters as a rule work well when leaving the factory, and will work well to the end of the time of utility of the machine—if properly attended to.

KEEPING MECHANISM CLEAN.—The mechanism governing them must be kept scrupulously clean, and well oiled with a lubricant of high quality—good clock oil, for instance. An oil with the slightest tendency to become gummy will be fatal to the perfect action of most of these devices. Being lightly made, containing many joints, and usually having sliding fittings in some part of their anatomy, they are especially liable to stick if not quite clean, and to bind if they receive the smallest injury. Usually a pair of governor balls, or a disc mounted on a spindle by a pin-joint on which it can turn through several degrees of arc in a direction at right angles to the main spindle, constitutes the actuating mechanism. The governor balls are, or the disc is, usually opposed by a spring acting in antagonism to the position they tend to assume during rotation. A sleeve sliding on the spindle, and having a groove into which a lever connected to the shutter works, is usually the means of connection between the rotating governor and the non-rotating shutter parts. Both the rod on which the sleeve slides, and the end of the lever engaging with the sleeve, should have special attention as to cleanliness, and should be wiped and oiled daily, if any dependence is to be placed on the device. Some of the shutters work on pin joints; others run on slides, and in the latter case the slides should also have special attention paid to them. It needs but a very small accumulation of dirt to cause a light-running slide to bind, and all these devices are necessarily light running. Some are provided with an adjustment by which they can be regulated to close at any desired speed, usually by altering the strength of the opposing spring. The details of design vary considerably in different makes of projector, but the principle is almost the same in all. The only advice to be offered is—if you wish the automatic shutter to work well, keep it clean, and guard it from injury, and when you have done this, do not depend upon it, but depend upon your own manipulation of the hand cut-off in case of stoppage of the film.

IMPROVED AUTOMATIC CUT-OFF.—To some of these automatic shutters is added an attachment which causes them to cut off in the case of either the upper or lower loop of the film pulling tight or becoming too large; so that should anything go wrong and cause the film to stop in the gate, the cut-off shall act although the machinery still runs at its normal speed. This sounds like a great improvement, and if it can be effected without introducing complication, should be of utility; but even with this addition, there still remains the danger that a piece of celluloid may shear off the edge of the film and remain caught in the gate in the path of the rays, when, if the operator be not alert, the result may be a burn-up, in spite of the automatic mechanism. This may seem a somewhat re-

mote contingency for which to provide; but it has occurred twice in the writer's experience. The proper thing is to at once shut off and remove the loose piece from the gate, because, should it ignite, it may be carried along with the film, and fall into the lower loop. Some automatic shutters are provided with a catch to hold them out of action while the light is being adjusted to give an even appearance on the screen, and should the operator forget to set the shutter free before starting the machine, the device remains inoperative. It is therefore advisable to completely remove this catch, because it is so easily possible to forget to set the shutter free. In adjusting the light, the shutter can be held open by the finger, and will always be ready for action when the film is threaded up, or an arrangement to automatically set free the shutter catch when opening the gate could easily be devised.

HAND CUT-OFF.—Whether dependence be placed on an automatic shutter or not, it should be an axiom with every operator to see that the hand cut-off works easily and certainly, so that it can be closed by a touch of the finger, and that it will remain closed, and not be liable to jar open, also that its lever is in a convenient and easily-reached position. A certain amount of confusion exists owing to the fact that all hand cut-offs do not act in exactly the same way, and that some require to be pushed and others pulled, and that the direction of the pushing and pulling is different in different makes. The County Council might attend with advantage to this special point.

THE INTERMITTENT MECHANISM.—We now come to the intermittent mechanism; the particular part upon which the excellence of the effect on the screen depends. This is also the quickest moving part, and subjected to the greatest strain, and here, also, the greatest amount of wear takes place. Perfect lubrication and particular cleanliness will conduce to long life of this part, and the steadiness of the picture will be maintained for a time, more or less long, according to the amount of care taken. The element of unsteadiness often lies to a great extent in the faulty treatment of the film before the operator handles it, but if the projector be not in good condition, still more faults of imperfect registration will be added, and the effect on the screen will be poor indeed.

PARTS REQUIRING SPECIAL CARE.—In the dog, or beater machine, the spindle on which the beating arrangement runs should always be kept well oiled, and when dirty oil shows at the ends of the bearings, it should be wiped off to prevent it again entering the bearings, and carrying into them the accumulated dust and grit. Should this be allowed, the spindle will soon get ground smaller, and the bearings larger, and the resulting loose fit will ruin the steady performance of the machine. The beating roller also requires special attention for the same reason, because should its fit on the supporting pin become slack, much unsteadiness of the picture will result.

THE BEATING ROLLER.—The beating roller is usually cleared away in the middle of its length, leaving two flanges, so that it may touch the film only at the

edges. These flanges on the roller tend to wear out of parallel, and to become conical, with the smallest diameter towards the centre. When this occurs, the machine should be sent to the maker for a new beating roller to be fitted, or for the worn one to be corrected. A beating roller worn out of parallel will always give an unsteady picture.

CARE OF MALTESE CROSS.—The remarks at the commencement of this article apply even more forcibly when the intermittent movement of the projector consists of a Maltese Cross, or any of the several forms of pin or claw action. With machines of this type great care must be taken, or rapid deterioration of result will inevitably take place. Many of the Maltese Cross machines are now fitted with an oil bath surrounding the intermittent mechanism, and, consequently, do not so often require overhauling; but the oil-bath itself may contain some grit and should therefore be emptied of oil and cleaned out from time to time; more often when the machine is new, because it may contain chips and grit remaining from the process of manufacture.

THE PIN AND CLAW MOVEMENTS.—The pin and claw movements must be kept very clean. Being the least durable, wear very soon becomes apparent, and those possessing machines of this type cannot give too much attention to keep the intermittent mechanism, of whatever form, clean and well oiled. The oil for lubrication should also be carefully selected. Too thin an oil will allow the spindles to rub on the bearings, and wear will be rapid. Too thick an oil will make the machine run heavily. Some oils dry to a certain extent and become gummy, and nothing short of getting rid of the half-dried oil by washing out the bearings with paraffin or petrol will make a machine run properly after having been lubricated with such an oil.

REMOVING OLD OIL.—When cleaning, be sure to get rid of the paraffin prior to re-oiling. This must not be forgotten before working the machine again. Petrol dries so quickly that if used for this purpose it must be wiped off directly it comes through the bearings, bringing the thick oil and dirt with it. If left, it will evaporate and leave the oil and dirt nearly in the same condition as before it was used. Mineral oils are now generally used for lubricating. Some are fairly good, and all are cheap, which latter fact may account for the now almost general neglect of the good old-fashioned neat's-foot oil. This costs much more to purchase than these mineral oils, but is by far the cheapest to use in the end, being of a more greasy nature, and consequently going much farther. It also retains its lubricating qualities for a long time in use, so that one treatment with this oil will usually outlast several applications of a mineral oil. The machine also will run more smoothly, wear less, and last longer in good condition. Unfortunately, it is difficult to obtain this oil pure and free from acid.

A GOOD OIL.—If some of the ordinary neat's-foot oil be put in a bottle and shaken up with some bright lead shavings, after a time the clear part, which will come to the top of the mixture, will be found the

finest lubricant possible for all machinery of which the projector is a type, and a very small quantity will go a very long way.

THE GEAR-WHEELS.—When the gear-wheels of a projector become worn and somewhat slack in fit, a great deal of the noise may be prevented by using beeswax on the teeth. Take a small lump and press it against the wheels while turning the machine, and if the teeth are free from oil it will adhere to the faces of the teeth and form a comparatively soft pad on each. The amount which works out at the sides of the teeth may be easily removed by holding a pocket-knife to the side of the wheel. No oil should then be put on the teeth.

SETTING THE SHUTTER.—The shutter of the projector sometimes becomes displaced, and smears and streaks from each bright part of the picture appear on the screen, showing that the shutter requires adjusting. This effect is especially noticeable when showing the bright letters of a title on a black ground.

To set the shutter, proceed as follows: Turn the handle, and note which way the shutter revolves. Put a piece of film in the machine, a length of 2 ft. or 3 ft. will be sufficient; turn the handle, and rotate the shutter two or three times; then, turning very slowly, notice the point at which the film commences to move, watching it as it enters the top of the gate. Turn the machine till the shutter just covers and note if the film begins to move. If not, the shutter must be shifted till this condition is fulfilled. Screw the shutter up lightly, using only one of the screws. Then turn the handle further, and note the point at which the film ceases to move; the shutter should then be just covering the lens aperture to the same extent as when the film just started. If not so, set the shutter forward or backward till equal amounts of the lens are covered at the starting and stopping points of the film, and screw up all set screws quite tightly. Some shutters have two or more blades attached to the same boss; when this is the case, the largest of the blades is the one by which the setting is to be done.

A three-bladed shutter is fitted to some of the modern projectors, and in setting this form of shutter it will often be found that there is no position in which a blade can be made to cover the lens or obliterate the light during the whole of the movement of the film. When this is the case titles will always show smears, and if the smears appear equally above and below the letters that are in the centre of the title, the best possible setting of shutter has been attained. To prevent the smears showing at all, it will be necessary to increase the width of one of the blades to an amount sufficient to allow the film to start and come to rest while the blade obliterates the light. The three-bladed shutters alluded to suppress flicker in a remarkable manner, but in doing so cut off half the available light. Increasing the size of one blade cuts off still more light. To compensate this loss, it is advisable to reduce the width of the other two blades each by half the amount added to the obliterating blade.

CHAPTER X.

Operating, and Faults to be Avoided.

1. *Adjusting the Light*—2. *Color on the Screen*—3. *Lantern Slide Attachments*—4. *Condition of the Gate*—5. *Threading Film in the Machine*—6. *Speed of Projection*—7. *Film Break*—8. *General Rules*—9. *Comfort of the Audience*—10. *Seating Arrangements*—11. *Lecturing to Pictures* — 12. *Lighting Arrangements*—13. *Lantern Slides*—14. *Watch the Picture*—15. *Avoid Showing White Screen*—16. *Advantage of Black Margin Around Screen*

WHEN the operator enters the operating chamber, in which all his apparatus is set up ready for work, there are a few items which should have immediate attention.

The illuminant must first be got ready, and care must be taken that it is working well. If the illuminant be limelight, the limes should be warmed and the jet put through its movements to test its working in accordance with the instructions given in the section of this book devoted to limelight. If electric light is to be employed, the carbons must be renewed (if not long enough to last out the show), and the lamp should be worked to see that none of its parts bind or stick. In any case the lantern should be brushed out to get rid of any accumulations of lime or carbon dust, as the case may be, and the moving parts of the jet or arc-lamp cleansed from any dust remaining from the last performance.

In putting in new carbons, first see that the elevator of the lamp is in the middle of its travel, so that in case of a piece of one carbon breaking off, or should one carbon burn more rapidly than the other, there shall be plenty of movement on the elevator rack to allow of re-centring the arc. Next give a minute to the take-up mechanism, and see that it works properly, and that the friction drive is neither too strong nor too weak. If driven by a band see that that also is doing its work satisfactorily. Then light up and centre the light on the screen. To do this quickly proceed as follows: Look at the disc of light thrown by the condenser on to the gate (or gate shield, as the case may be), and if it be not central in relation to the opening or mask, make it so by working the knobs of the electric lamp, or elevating or depressing the lime-jet, or placing either more to right or left as may be required. The size of the disc of light thrown on the gate must next be taken note of. With the arc-light a fairly sharp circle of light is seen on the gate, and this should be of such a size as to completely cover the opening in the gate. The surrounding ring of reddish color should be large enough to just clear the film opening; if not, red parts will be seen towards the sides of the screen. To make this circle larger, it is necessary to put the light closer to the condenser, the reverse action producing the opposite effect. If this circle be made too large, the best

light will not be obtained. With limelight the circle of light on the gate is somewhat more diffused at the edges, and these diffused edges again must be made to fall outside the opening. Until the circle of light is both central and of the correct size on the gate, no notice of the screen need be taken. When the light appears correct on the gate, the final adjustments can be made by looking at the screen. It is seldom that much further adjustment will be required.

Having adjusted the light for the bioscope till the screen is evenly illuminated, attention should at once be given to the light from the lantern slide attachment. In some machines lantern slides are shown by swinging the bioscope out of the way of the rays from the condenser, and at the same time bringing the lantern objective in line. Place a lantern slide in the carrier, and see that the light is good and that the focus is correct. Many lantern attachments are made to run on slides, so that instead of swinging the machine out of the way the lantern itself is pushed bodily along a pair of rails until it is in optical line with the lantern lens, or, if the machine be on rails, this must be moved. The adjustments for either style of machine are similar, and need no further description.

The next point to which the operator must give special attention is the condition of the gate. This should be quite clean, polished, and free from dust; and should the smallest amount of roughness or drag be felt when the fingers are passed over the bright parts a small—very small—amount of vaseline should be applied; and even this small portion should be then almost completely removed by means of a rag kept for the purpose.

Now change over from the one arrangement to the other, and see that both are in focus, and that the illumination is good. Shut the hand cut-off and proceed to thread the film, having, of course first seen to oiling of the machine, as described in a previous chapter. It has already been explained how to get the film the right way round. To thread it, take the end of the film, pull out sufficient to pass completely through the machine, and to reach the take-up spool; slip it under the top sprocket wheel, seeing that it engages properly with the teeth. Allow a loop of film, and pass the film through the gate, and shut it securely. In using a machine of the "dog" or beater type the film is then to be passed under the beater, and without allowing a second loop, over the lower sprocket and direct to the take-up spool. Should the machine be fitted with an auxiliary sprocket a small loop of film must be allowed between the two sprockets.

In threading a Maltese cross machine care must be taken to also leave a loop of film between the small intermittent sprocket and the take-up sprocket, and a similar loop below the gate is required by a pin or claw mechanism. Before closing the gate of the latter type of machine be sure that the pins or claws are properly entered into the perforations, otherwise much damage may be done to the film. When the lower sprocket has been threaded it only remains to

attach the end of the film to the take-up spool. Give the handle of the machine about half a turn to see that all is in working order, and adjust the position of the gate aperture to suit the picture. In some machines with only a small latitude of travel in the gate aperture, it may sometimes be necessary to shift the position of the film to the extent of a perforation or two. In all cases it is advisable to set the gate aperture to the middle of its travel before threading, and to thread so that the picture will then correspond with the gate aperture. In most machines, moving the gate from the central position causes the picture to be out of the optical centre of the machine. and a more or less degraded intensity of light is the result. A slight alteration in the height of the illuminant will correct this. If a lantern slide is first to be shown, place this in the carrier, and put the machine in position to show it as soon as the cut-off is opened; then the cut-off can be again closed, the bioscope readjusted in position, and the moving the oiling of the machine, as described in a previous picture part of the show proceeded with.

Always give an eye to the take-up mechanism, particularly when the spool is becoming full, as this is the time when failure is most likely to take place. Meanwhile the light will also require attention. With an arc lamp, the carbons must be fed forward at intervals of one to two minutes. The less electric power there is, the less feeding will be required. With a powerful lime-jet, the lime must be carefully watched, and it should be turned sufficiently at intervals of two or three minutes, just enough to bring a fresh surface of lime into contact with the gases; with a smaller light less attention will be required. During a show, carbons may burn somewhat out of centre, and when this is noticed, by the top or bottom of the screen becoming less brightly illuminated, the necessary adjustment should be made by means of the elevator.

The screen must also be watched to see that the machine is giving a reasonable rate of movement to the picture. Walking figures should walk, not progress in a series of stilted jerks; running figures should run, not fly across the screen; jumping figures should rise in the air and fall as they do in nature, not bounce like air-balls, as will appear if the machine be turned too slowly. When using limelight, the operator must also watch his light and make any corrections for centring, feeding, or turning limes, as the case may be, adjusting the gases from time to time as the lime wears out, or even altering the distance from the lime to the nipple to compensate for want of roundness in the lime itself. Should anything unusual or unexpected happen, he must act promptly and without hesitation, doing the right thing; but not hurriedly, or he may only lose time. Should the film break—and this not infrequently occurs—he must at once shut off the light, run the machine a few revolutions, re-thread the gate and the lower sprocket, and with a pin attach the broken ends, and see that in doing so they are placed sufficiently level to wind on the spool without binding. If this is done promptly the pause will be so small that the

audience will scarcely be aware that anything has happened. But should any hitch occur likely to occupy much time in putting right, the advantage of always having a lantern slide on the carrier will be apparent, as it is only necessary to turn the bioscope part of the machine out of its position and throw the lantern slide on the screen while the necessary repairs are being carried out to the film, the machine, the take-up, the lamp, or whatever may have been deranged.

All this time the operator must, in homely phrase, "have all his wits about him." These operations may seem somewhat complicated and confusing, and will undoubtedly be so to the tyro; but with a small amount of practice many of the movements become so automatic that soon little difficulty will be experienced in keeping all the various parts running in proper relation to one another. We must impress upon him, however, the necessity of not hurrying too much. A hasty and ill-considered action will in most cases prove to be the wrong one, and result in disaster; whereas, had he cultivated the virtue of coolness and method, a second's thought would have enabled him to do what was right.

The resistances should be placed outside the box, and in starting for the first time they should be watched to see that they can carry the current sufficiently well without overheating. If not, larger resistances, carrying more amperage, should be obtained, or two or more of the same size as previously found deficient put in parallel.

Finally, the particular items to be attended to are the conditions of the following, placed in the order of their importance:—

1. The take-up mechanism.
2. The gate.
3. The elevator of the lamp.
4. The working of the automatic shutter.

If these are properly looked after much trouble will be saved to the operator and a greater measure of safety secured to the audience.

Often after attending a bioscope performance one comes away with the idea that something was not quite as nice as it might have been. Perhaps the light was bad and the screen in consequence dull. Perhaps the general arrangement of the program was not sufficiently continuous; pauses may have occurred during the performance, and altogether a feeling of want of finish was experienced. Now, it is necessary that a smart operator should give a performance in such style that every member of the audience shall leave with a feeling of satisfaction. One of the first things to be considered is the method of seating the audience. Avoid placing front spectators too near the screen, because people so placed become painfully aware of such defects as may be in the film, and even the best (photographic and otherwise) examples are liable to contain blemishes. The great amount of magnification necessary to cover a fairly large screen renders these unpleasantly apparent to those sitting too near. The highest priced seats should not be in the front, and, in the case of a very large hall, they

should not be at the back. In a small hall the back seats are the best, and should be charged for accordingly. For the lecturer, placed near the screen, it is always difficult to see the picture, and even, sometimes, impossible to say which exact part of the performance is proceeding.

To let a lecturer know how the picture is progressing, a convex mirror placed at a convenient position where it can be easily seen will show a diminished image, the whole of which is visible at a glance, and will save him the trouble of continually turning his back to the audience.

It is important, in order to produce the best effect, that the bioscope pictures should not commence *immediately* the lights are lowered. If this be done a large amount of flicker will be apparent, and at once will give a bad impression. It is far preferable to put on one or two slides, which should not be too bright, so that the eyes of the audience may become a little more sensitive to light. The iris of the eye opens and closes automatically; in a bright light it is small, in a dull light it is large in diameter. These changes take an appreciable time to occur, so if even a few seconds of darkness or subdued light can be allowed to act on the eyes of the audience, they will be in an improved condition to receive the sensation of light, and will retain the impression much more strongly. The fault of being too quick between "lights out" and "pictures on" is one especially to be avoided.

When the slides appear, be sure they are put in the right way round and the right way up; also that the carrier in which they are used is correctly centred and quite level. A very slovenly effect is produced by showing a slide not properly placed on the screen. These points should all be settled before the audience is admitted; and all slides should be properly spotted —pieces of the gummed edging of postage stamps are very convenient for this purpose when proper "spots" are not available. Do not jerk your slide about when its image is on the screen; it is much better to shut off the light for a moment and rectify any fault. See that the focussing of both the slides and the film are correct; it is irritating to an audience to see a picture out of focus, and should the operator's attention be claimed by the lamp just at the start, a large portion of a film may be shown on the screen in such a blurred and indistinct condition that disgust instead of satisfaction to the audience will be the natural result.

It is necessary to emphasise the extreme importance of having all adjustments thoroughly and completely in proper condition before the admission of the audience. The maxim which has often been applied to art—that the true aim of art is to conceal method—is especially true in connection with a bioscope performance. Do not let the audience know "how the trick is done"; the more mystery and the less exposure of method the better. The light should be centred, the picture placed properly on the screen, and the whole properly focussed; the lantern slides

should pass easily into the carriers, and be as easily removed, should be properly spotted, and should have been tested on the screen to see that all is quite correct. A lantern slide of an interesting nature should be kept on the screen longer than one which merely makes an announcement. On the other hand, one often sees a slide containing a lot of small reading matter, allowed to remain on the screen for so short a time that it is quite impossible for any member of the audience to read all the matter contained thereon. This is another great fault, because it leaves the audience with a vague idea as to what is going to happen, and is the cause of considerable unrest. Many persons will be asking their neighbours what is to be expected, instead of attending to the picture under progress. A very good way is for the operator himself to read the slide through slowly while it is on the screen; he may then be assured that the audience will be able to read it at the same rate. But to estimate the time taken to read a certain amount of printed matter will probably only result in a very erroneous impression.

The arc should be allowed to burn some few minutes before the light is required for the instrument, so that the carbon points may settle down to the proper shape, and when the top carbon requires shifting the adjustment can be done properly and completely before the show commences, instead of the operator having to try several positions while the machine is running; with the probable result that the light may vary at each alteration and possibly put the screen in darkness, or semi-darkness, from time to time.

The operator should watch the picture all the time. Sometimes a section of a film has been photographed much more slowly than the preceding and following sections, and should the speed on the machine be maintained throughout at an even rate, a tremendous amount of undue excitement will be shown in just the section which has been photographed slowly, to the detriment, in many cases, of the whole subject. The greatest fault one usually meets is that of pictures being run too quickly. When comic films are being run through, no particular harm may result, and with certain audiences the extra rush and bustle introduced by too quick running may be an advantage. Audiences are, however, getting more and more critical month by month, and the picture that depends for its fun on mere rough and tumble does not now generally give so great satisfaction as previously was the case.

Above all things, avoid showing a white screen. Before the end of the film arrives at the gate the light should be shut off. A ragged torn edge of a film "gives the show away" more than any other mistake that can be made, and the slovenliness of the operator is impressed on every spectator. Films are often joined up with a piece of unexposed stock, and in this case only a dull grey light is shown on the screen. This, although not so workmanlike as the proper shutting off of the light, is decidedly to be preferred to a white screen.

Always have a slide ready inserted in the lantern attachment in case of a breakage in the film. If the repair can be effected very quickly, cutting off the light for a few seconds is perhaps the best way out of the difficulty. Should, however, any delay beyond a few seconds occur, then the lantern slide should be thrown on the screen while the operator effects the necessary repairs.

The screen should have a black margin all round, almost touching the edge of the picture. It so happens that the sides of the retina of the human eye are more sensitive than is the centre, and anything white or light-colored in the neighborhood of the screen likely to attract attention and to reflect light into the eyes of the audience, will cause the latter to see considerably more flicker than if the surroundings had been kept dull or low in tone. No light should be allowed to fall on the screen other than from the machine. Even a candle placed on the pianist's table, if not properly shaded, both from the audience and from the screen, is able to cause a remarkable deterioration in the excellence of the picture. The screen in some cases should be sloped forward, especially when the operator is working from the floor of the hall on to a rather high screen; but it should not be sloped enough to place it at right angles to the optical centre of the machine, but only about half so far; otherwise, should there be galleries in the hall, or people sitting above the general level of the audience, a distorted picture will be presented to those positions.

In conclusion, the slovenly operator of the past will have no place in the best picture theatres of the future. We are now in the transition state, and it behoves every worker in this industry, film producer, manager, and operator alike, to do the best that is in him, and try to keep up with the foreigner, for there is no doubt the latter is getting in front. Through the past centuries Englishmen have been pioneers, and, until recently, always held a leading place in the business of the world. We are now beginning to realise the fact that there are many clever people who are not Englishmen, and it is necessary to put all "shoulders to the wheel" in the endeavor to get back what we have lost and again occupy first place.

CHAPTER XI.

THE OPTICAL SYSTEM OF THE BIOSCOPE.

1. *Theory of Illumination*—2. *The Condenser*—3. *Projecting Lens*—4. *Explanation of Conjugate Foci*—5. *Image Formation*—6. *Reasons for Reversion of Image*—7. *Adjustment for Position*—8. *Different Types of Condenser*—9. *The Projecting Lens*—10. *Two Useful Rules.*

WHILST it is by no means necessary for the bioscope operator to be deeply versed in the science of optics, it is of very great importance that he should be thoroughly familiar with the optical principles of his instrument, for without such knowledge he must inevitably carry out his work imperfectly, and with a feeling of uncertainty; while he cannot possibly hope, without having a clear grasp of those principles, to be able to obtain the best results at all times. It is a common saying, and one often quoted, that theory and practice are two different things, and the practical man is often inclined to discount the value of theoretical knowledge. But when those occasions arise, when something unexpected happens, something which has not been previously met with in practice, the man who is well grounded in theory will easily score over his purely practical rival, and by knowing the *reason* for the unusual results, will be able to rectify defects at once, instead of having to try one method after another till the correct solution may haply be found. When trouble arises the man who knows nothing of the theory of the subject takes turning after turning until he possibly hits the right direction, while the theoretical man—(who must also be practical)—is enabled, by his knowledge of theory, to take the right road on the first occasion.

The optical system of the bĭoscope differs but slightly from that of the optical lantern, and the same principles apply to both instruments, the most distinctive feature being the relative positions in the converging cone of rays from the condenser, in which the lantern slide and the film are respectively placed.

The optical system common to all projection apparatus consists of three main items:—

(1) The Source of Illumination.

(2) The Condensing System.

(3) The Projecting or Image-Forming Lenses.

THE SOURCE OF ILLUMINATION, which must be kept as small as possible, for a reason to be explained later.

THE CONDENSING SYSTEM consists of an arrangement of lenses so placed as to collect and concentrate the light and cause it to pass through

THE PROJECTING LENS, which, by focussing the image of the film upon the screen, forms the picture. Fig. 1 is a diagrammatic representation of the optical system: A being the source of illumination, B the condenser, C the projecting lens; the dotted line at D shows the position occupied by the film. HH is a

line drawn through the middle of the whole system, and is called the optical centre, and the lines EE FF show the boundaries of the cones of rays used. Any light falling outside these boundaries is wasted, and of no utility in forming the picture. G is the screen on which the picture is thrown.

In the diagrams, the lenses B and C are each shown as consisting of a single glass. In practice,

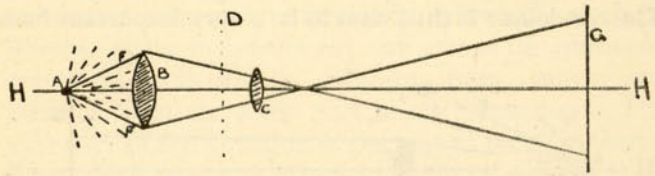


FIG. 1.

to produce good results, these lenses are each made up of combinations of other lenses, arranged to overcome, as far as possible, certain defects inherent in and belonging to all single lenses.

Without the aid of the condenser the outside rays EE and a very large proportion of those nearer the centre would not pass through the projecting lens, and would consequently be useless, as they would proceed in straight lines from the illuminant A. The diagram (Fig. 2) will explain this.

The light proceeding from the point A would radiate in all directions. The boundary lines of the useful rays would then be at KK, and these would be of very little use owing to their not travelling in the required direction; whilst all those rays lying between the lines EE and the lines KK, which in the previous diagram were shown as passing through the objective, would be absolutely useless for our purpose. To sum up; a small portion of the middle of the picture on the screen, not much larger in diameter than the projecting lens itself, would be fairly illuminated, and a small ring less bright and quickly fading into darkness would surround this not very brilliant centre. The condenser is thus seen to be a very important item

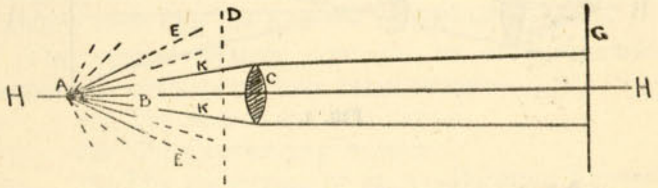


FIG. 2.

in the projecting system, and on its proper adjustment and suitable power much of the success depends. Its function is to collect as many of the illuminating rays as possible, and by concentrating them and bending them into the required direction, cause them to pass through the projecting lens after traversing the picture on the film. The dark parts of the photographic picture on the film (according to their respective opacities) intercept the rays more or less, and proportionate amounts of the light passing through the different parts of the picture eventually reach the

screen and form, by their corresponding arrangement of light and shade, an enlarged facsimile of the original small image.

This result cannot be obtained without the intervention of the projecting lens, which has the function of recombining on the screen any rays which have not passed in exactly the prescribed direction through the transparent parts of the film. Owing to the two facts that the source of illumination is larger than a mathematical point, and that imperfections in the condenser cannot be completely corrected, a large number of the rays from any one part of the condenser travel in paths widely different from other rays coming from the same part of the condenser. This diversity of the direction of the rays is much increased when the illuminant is considerable in size, as in the limelight, acetylene, or oil lamp, but the employment of a projecting lens causes these seemingly erratic rays to recombine on the screen, and a sharp image is the result.

When a point of light is placed at a distance from a convex or magnifying lens, one of three things happens— *viz.*: If placed at a less distance than what is known as the principal focus of the lens, the rays of light after passing through the lens will proceed in a divergent direction, as at Fig. 3.

If the point of light be at the distance of the principal focus, the emanating rays will be parallel as at Fig. 4. If the light be placed beyond the principal focus, the rays, after traversing the lens, will recombine and come again to a point more or less distant, according as the original point is more or less distant. Figs. 5 and 6 show two conditions, one in which the points A and B are at equal distances from the lens,

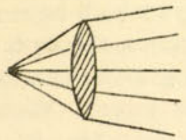


FIG. 3.

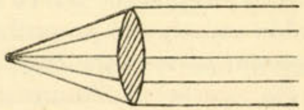


FIG. 4.

and another in which point A has been brought nearer to the lens, causing a lengthening of the distance to point B. These points A and B are called the "conjugate foci," and are quite interchangeable the one with the other. If a light be placed at A, Fig. 5, the image of the light, reversed in position, will be formed at B. If it be placed at B the image will be formed

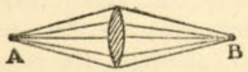


FIG. 5.

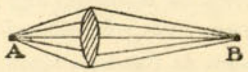


FIG. 6

at A. The same applies to Fig. 6. Advancing point A steadily towards the lens will cause point B to recede, at first slowly, and as the distance from point A to the lens more nearly approaches the principal

focus, point B will recede more and more rapidly until, owing to the lines becoming parallel, as in Fig. 4, the point B will not be formed at any distance, however remote. A proper understanding of the simple laws governing the conjugate foci of lenses will make it easy to appreciate the cause of all the optical part of the science of projection. From the foregoing it will be evident that to get the greatest amount of light to pass through the projecting lens and reach the screen (*see* Fig. 1, page 133), it will be necessary to place the illuminant at the proper distance from the condenser. If placed too near, the light will be too much spread out, and if too far, it will be too small and concentrated to cover the whole of the picture on the film.

We now come to the somewhat more complex subject of image formation, and to explain this it will be necessary to study some further diagrams. The condenser is not required to form a perfect image, but only to throw the light through the projecting lens so that it may be evenly distributed over the surface of the screen. It would, however, when properly adjusted for even illumination, throw an imperfect image of the source of light somewhere between the projecting lens and the screen. This image may be easily seen if the projecting lens be taken out of its fitting and a piece of cardboard held in the path of the rays and moved towards the screen until the image is in focus.

When an image, a candle flame for instance, is placed at a distance from a lens greater than its principal focus, a reversed image is formed at the conjugate focus, and this image is larger or smaller according to the distances of the conjugate foci from the lens. If the candle flame be placed so that its distance from the lens is less than the distance of the image formed at the conjugate focus, that image will be larger than the candle flame from which it was formed—and *vice versa*.

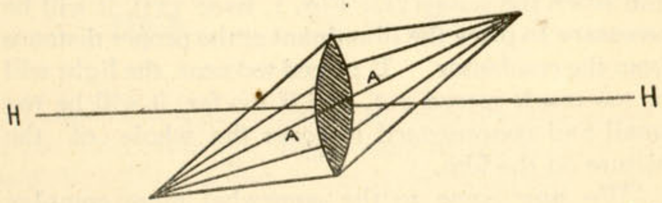


FIG. 7.

The central rays are those which pass through the centre of the lens. They proceed in practically straight lines, as shown in the preceding diagrams, where the central rays have also been shown as coinciding with the optical centre. If, however, rays from a point not on the optical centre pass through a lens the central ray still proceeds is a straight line (Fig. 7), HH being the optical centre, and AA the central ray. Taking only the central rays from two points, the reason will be easily seen in Fig 8, where A is the lens, and two of the central rays only are shown.

But from every point in the candle and flame an infinite number of rays start in all directions, and the number of points on the candle and flame are also infinite, and it is consequently quite impossible to convey by means of a diagram an idea of all these rays and their paths, as the whole diagram would soon disappear in one dab of ink, so we will take just two points, A and B, Fig. 9, from which the light proceeds, and show the way in which the images of just those two points are formed at A^1 and B^1 respectively.

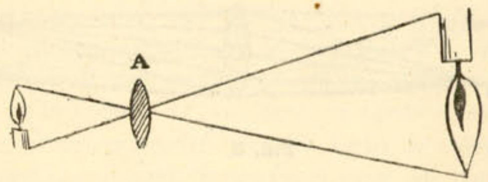


FIG. 8.

From every point in the original image a number of rays start in all directions, but only those which pass through the lens are shown in the figure, and only such as come from the two points in question.

Now placing our film with its photographic picture in the position of AB, it is easy to see how the image is formed on the screen placed at A^1 and B^1. Wherever the light from the condenser can get through the film, each point in the illuminated film allows its bundles of rays to pass to the projecting lens, which recombines them on the screen, and out of a multiplicity of light and dark points, each in its relative position, the picture is formed. On referring again to Fig. 1, it will now be evident that in order to have a clear image on the screen the film must occupy the position of one of the conjugate foci of the projecting lens, while the screen will occupy the other conjugate point. Moving the lens C nearer to the film D, the image on the screen G will have to be at an increased distance, and *vice versa*: so it is easy by

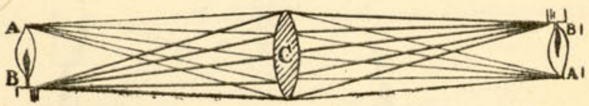


FIG. 9.

moving the lens to make the image of the film suit the position of the screen. This operation is called "focussing the picture."

It has already been pointed out that moving the light A to or from the condenser B causes a displacement of the point I in a similar manner. Arriving at the correct point by this means is called "focussing the light." It is also necessary that the light A, the centre of the condenser B, the film picture D, and the projecting lens C, should be in the same straight line, or, in other words, in the optical centre. The process of adjusting the light so that it may exactly coincide with this line is called "centring the light."

The theory of the optical lantern by which slides are shown is almost exactly similar to that of the bioscope. Owing to the larger size of the lantern slide pictures (which may be 3 in. square, instead of 1 in. by ¾ in., the size of a film picture), it is necessary to place the larger picture near to the condenser, in order that the light rays may pass through all parts of it. With this small difference all the foregoing facts apply equally to the theory of lantern optics.

THE CONDENSER SYSTEM. The usual diameter of the lenses used in the bioscope condenser is 4 in., though 4½ in. is sometimes fitted. Both larger and smaller sizes have been employed, but it is seldom that they are met with in modern practice. These sizes have the advantage of being fairly cheap to purchase, and are large enough to cover a lantern slide. Cheapness is an item in continuous work, because when powerful electric light or limelight is employed, breakages occur from time to time, and renewals are consequently frequent. A cracked condenser will often serve to illuminate a film picture, because, being placed at a considerable distance away from the film itself, it is "out of focus" as regards the lens, and the crack is not defined on the screen at the same time as the film picture. In showing a lantern slide, however, a cracked condenser is fatal to good effect, because its distance from the lantern slide is small enough to allow the projecting lens to define the crack unpleasantly sharply on the screen when the slide is also in focus. Many bioscopes are arranged also to show lantern slides, and in these a cracked condenser must be immediately replaced by a new one. Two forms of condenser are in general use, and several modifications have been employed from time to time, mostly for special purposes. The most common form consists of two plano-convex lenses of equal focus, giving together a combined focus equal to from 3 in. to $3\frac{1}{2}$ in.

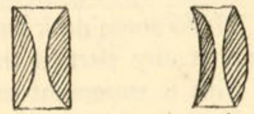
The lenses are mounted with their convex sides towards one another, and nearly touching. This form has great advantages over a single lens of the same focus, its arrangement of curves tending to correct the great defect called "spherical aberration," found in all single lenses; which defect in a condenser shows itself in the form of uneven illumination on the screen. Spherical aberration being too complex a subject for a manual like the present, readers are referred to treatises on optics should they wish to study this subject more fully. The double plano-convex form of condenser does not completely do away with all spherical aberration; a considerable amount remains, and will render itself unpleasantly evident should a long focus projecting lens be used in conjunction with this form.

Another and better form of condenser is the "meniscus," which consists of a meniscus, or "moon-shaped" lens combined with a double convex lens. The convex side of the meniscus lens is placed towards the double convex lens, and again the two lenses nearly touch one another. The focus of the complete condenser is about the same as that of the double plano-convex form. The spherical aberration is

further corrected, and when using long-focus projection lenses, its employment is almost imperative. Below are diagrams of the two forms.

It is immaterial which side of the "plano" condenser is turned towards the light; the "meniscus," however, must have its concave or hollow curve facing the light. If reversed, it will show nearly as much spherical aberration as a single lens.

Condensers containing three and even four lenses have been made, and are possessed of undoubted



PLANO CONVEX MENISCUS

advantages, both as to light-grasping power and freedom from spherical aberration, but owing to their extra cost and their extra liability to crack, they are now little, if ever used. Condenser lenses should fit loosely in their mounts; expansion and contraction during heating and cooling may cause them to crack. A tight mount cools and contracts sooner than does a glass lens, and may cause trouble, but this is unlikely. The principal damage to condensers comes from sudden or uneven heating or cooling; this will be treated of in a later chapter.

THE PROJECTING LENS. We now come to consider the image-forming or projecting lens, which is an optical production of much higher finish and excellence than the condenser. The spherical abberration is almost completely correct, and another correction which is not attempted in the condenser, but imperatively necessary in any lens which has to form a sharp image, has been added. This is the correction for colour, or achromatism. It is not necessary here to explain the word achromatism, beyond saying that a lens not achromatised would produce but a poor image on the screen. Many parts of the picture would be fringed with colour, which fringes would be very pronounced when a black object joined a white one, or where a clear sky joined some dark part of the picture. No crisp definition of any part of the picture would be possible, and with a statement of these facts we will leave the subject of achromatism, which may be studied in optical treatises by those who wish for a little extra intellectual occupation.

The form of lens used for bioscope projection is known as the "Petzval," so called because Petzval first computed the curves for a portrait lens many years before animated pictures came to the experimental stage. This "Petzval" form of lens was subsequently found to be very suitable for use in the optical lantern, and although it has been improved somewhat since Petzval's time, its main principles remain as he left it.

It consists of four distinct glasses arranged as follows: the glasses are in two pairs—one pair at each end of a brass tube. The two glasses at the front

are cemented together and cannot be separated. They are held in a cell which screws in one end of the tube. The other two lenses are separated by a brass ring against which they are held by being screwed into a cell, which itself screws into the other end of the brass tube.

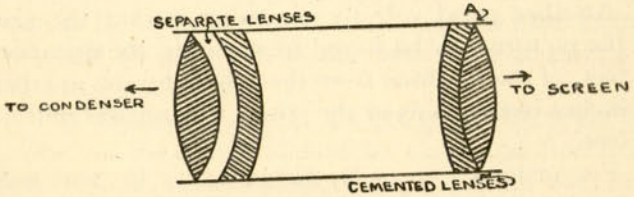


FIG. 10.

It is unnecessary to describe the lenses in detail; a reference to the diagram Fig. 10 will show at once the styles of the lenses and the correct way of putting them in their mount. The operator should make himself quite familiar with the construction of this lens. Omission to place the lenses in their correct position after removing them for cleaning will result in very poor definition on the screen.

A very good rule to remember is that in putting this lens together, all pronounced curves bulge towards the screen. The curve marked A in Fig. 10 cannot be seen, so will not help to confuse, nevertheless it is quite easy to make a mistake, and particular care should be taken when putting this lens together.

Projecting lenses are of different foci, according to the size of picture they are required to give, and the distance from the screen at which the bioscope is to be placed.

The foci range from $1\frac{1}{2}$ in. to 6 in., the former being very seldom used, and the latter only in the case of very long halls.

Another good rule to remember is that the size of the picture may be found by dividing the distance, in feet, of the machine from the screen by the number of inches in the focus of the lens. The answer will be in feet.

For instance: at 40 ft. distance, a 4 in. lens will give a 10 ft. picture; at 30 ft. a 2 in. lens gives a 15 ft. picture; at 12 ft. a $1\frac{1}{2}$ in. lens gives an 8 ft. picture, and so on.

This rule is not rigidly true, because it is seldom that the mask of a projector measures a full inch from side to side, 15-16ths of an inch being about the average size; so on this account alone the picture will be somewhat smaller than the above rule states; but another discrepancy will also often be met in practice. The numbers indicating the foci of the lenses which are usually engraved on the brass tubes, very often do not indicate the *exact* focus, and the resulting picture may prove to be larger or smaller than the rule gives, according as the lens is shorter or longer in focus than the amount stated. The rule, nevertheless, will be found extremely useful, as it gives in most cases a close approximation to the distance at which it is required to place the projecting apparatus from the

screen, and will save much time in setting up the machine.

The source of illumination may consist of any method of obtaining a sufficiently powerful light.

Whatever form of illumination be employed it is essential that it shall be of a concentrated description. A large flame, however bright, is of little use. A point of light, as in the electric arc, is the ideal condition, and an approach to the same state of things is made in the limelight.

THE CARE OF LENSES. To get good effects on the screen, all the lenses should be clean and free from dust. This remark applies especially to the projecting lenses, for if their surfaces are smeared with oil, or if they are covered with dust, light will be lost and definition be poor.

A clean, soft linen rag, an old pocket-handkerchief that has been many times through the wash, is the best possible thing to use for cleaning lenses of all kinds. It should be applied lightly at first to remove dust particles, should then be thoroughly shaken, and afterwards may be used with more force to remove smears, should they be apparent when the glass is breathed upon. The glass surfaces should *never* be touched by the fingers, because perspiration marks are extremely difficult to remove completely. Oil smears are also difficult to clean, and traces will remain and re-appear time after time, in spite of the most careful cleaning in the ordinary way. Pure alcohol, or petrol, may be used to get rid of any marks which cannot be cleaned off by merely breathing on the lens and wiping with the linen rag. Chamois leather *is not* good, because it so easily accumulates dust, among the particles of which there are hard pieces—hard enough to scratch glass.

The projector lens mounts usually have marked upon them the equivalent focus of the lenses they contain. The equivalent focus is the result of all the lenses as mounted in the tube, and must not be confused with the "back focus" quoted in some catalogues. To find the equivalent focus of a lens which is not marked, hold the tube by two fingers at about the middle position, and let the rays from the sun, or a distant point of light, pass through it on to a white surface, or get an assistant to hold a piece of card at such a distance that an image of the sun (or of whatever other light is used) falls on the card. Get the image as sharp as possible, and then, with the other hand, rock the tube slightly between the two fingers. If the image does not move, the equivalent focus of the lens is the distance measured from the point where the lens is held to the card. If the image moves from side to side when the tube is rocked, the lens must be shifted to a new position between the fingers, until a point is found when on rocking the lens the image remains stationary.

The back-focus above-mentioned is the distance measured from the back lens to the card when the image is sharp, th eback lens being nearest to the card in making this latter measurement. The card in both instances should be held square to the axis of the lens.

It is sometimes difficult, without taking apart, to know which is the back glass of a projection lens. To find this quickly, hold the lens in a good light—in the rays from the arc lamp, for instance—when on looking sideways at the inside edge of the glasses, the back end will be at once evident, owing to the separation between the lenses of the back combination, and a whitish rim like ground glass showing up very clearly.

APPENDIX

CINEMATOGRAPH ACT

(1909).

[9 Edw. 7 Ch. 30.]

ARRANGEMENT OF SECTIONS.

CHAPTER 30.

An Act to make better provision for securing safety at Cinematograph and other Exhibitions.

Be it enacted by the King's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons in this present Parliament assembled, and by the authority of the same, as follows:—

Provision against Cinematograph Exhibition except in Licensed Premises.

1. An exhibition of pictures or other optical effects by means of a cinematograph, or other similar apparatus, for the purposes of which inflammable films are used, shall not be given unless the regulations made by the Secretary of State for securing safety are complied with, or, save as otherwise expressly provided by this Act, elsewhere than in premises licensed for the purpose in accordance with the provisions of this Act.

Provisions as to Licences.

2.—(1) A county council may grant licences to such persons as they think fit to use the premises specified in the licence for the purposes aforesaid, on such terms and conditions, and under such restriction as, subject to regulations of the Secretary of State, the council may by the respective licences determine.

(2) A licence shall be in force for one year or for such shorter period as the council on the grant of the licence may determine, unless the licence has been previously revoked, as hereinafter provided.

(3) A county council may transfer any licence granted by them to such other person as they think fit.

(4) An applicant for a licence or transfer of a licence shall give not less than seven days' notice in writing to the county council and to the chief officer of police of the police area in which the premises are situated of his intention to apply for a licence or transfer:

Provided that it shall not be necessary to give any notice where the application is for the renewal of an existing licence held by the applicant for the same premises.

(5) There shall be paid in respect of the grant, renewal, or transfer of a licence such fees as the county council may fix, not exceeding in the case of a grant or renewal for one year one pound, or in the case of a grant or renewal for any less period five shillings for every month for which it is granted or renewed, so however that the aggregate of the fees payable in any year shall not exceed one pound, or, in the case of transfer, five shillings.

(6) For the purposes of this Act the expressions "police area" and "chief officer of police," as respects the City of London, mean the City and the Commissioner of City Police, and elsewhere have the same meanings as in the Police Act, 1890. (53 and 54 Vict. c. 45.)

Penalties.

3. If the owner of a cinematograph or other apparatus uses the apparatus, or allows it to be used, or if the occupier of any premises allows those premises to be used, in contravention of the provisions of this Act or the regulations made thereunder, or of the conditions or restrictions upon or subject to which any licence relating to the premises has been granted under this Act, he shall be liable on summary conviction to a fine not exceeding twenty pounds, and in the case of a continuing offence to a further penalty of five pounds for each day during which the offence continues, and the licence (if any) shall be liable to be revoked by the county council.

Power of Entry.

4. A constable or any other officer appointed for the purpose by a county council may at all reasonable times enter any premises, whether licensed or not, in which he has reason to believe that such an exhibition as aforesaid is being or is about to be given, with a view to seeing whether the provisions of this Act or any regulations made thereunder and the conditions of any licence granted under this Act have been complied with; and if any person prevents or obstructs the entry of a constable or any officer ap-

pointed as aforesaid, he shall be liable, on summary conviction, to a penalty not exceeding twenty pounds.

Power of County Councils to Delegate.

5. Without prejudice to other powers of delegation, whether to committees of the council or to district councils, a county council may, with or without any restrictions or conditions as they may think fit, delegate to justices sitting in petty sessions any of the powers conferred on the Council by this Act.

Application to County Boroughs.

6. The provisions of this Act shall apply in the case of a county borough as if the borough council were a county council, and the expenses of the borough council shall be defrayed out of the borough fund or borough rate.

Application of Act to Special Premises.

7.—(1) Where the premises are premises licensed by the Lord Chamberlain the powers of the county council under this Act shall, as respects those premises, be exercisable by the Lord Chamberlain instead of by the county council.

(2) Where the premises in which it is proposed to give such an exhibition as aforesaid are premises used occasionally and exceptionally only, and not on more than six days in any one calendar year, for the purposes of such an exhibition, it shall not be necessary to obtain a licence for those premises under this Act if the occupier thereof has given to the county council and to the chief officer of police of the police area not less than seven days before the exhibition notice in writing of his intention so to use the

premises, and complies with the regulations made by the Secretary of State under this Act, and, subject to such regulations, with any conditions imposed by the county council and notified to the occupier in writing.

(3) Where it is proposed to give any such exhibition as aforesaid in any building or structure of a movable character it shall not be necessary to obtain a licence under this Act from the council of the county in which the exhibition is to be given if the owner of the building or structure—

(*a*) has been granted a licence in respect of that building or structure by the council of the county in which he ordinarily resides, or by any authority to whom that council may have delegated the powers conferred on them by this Act; and

(*b*) has given to the council of the county and to the chief officer of police of the police area in which it is proposed to give the exhibition not less than two days before the exhibition notice in writing of his intention to give the exhibition; and

(*c*) complies with the regulations made by the Secretary of State under this Act, and, subject to such regulations, with any conditions imposed by the county council, and notified in writing to the owner.

(4) This Act shall not apply to an exhibition given in a private dwelling-house to which the public are not admitted, whether on payment or otherwise.

Application to Scotland.

8. This Act shall extend to Scotland subject to the following modifications:—

(1) For references to the Secretary of State there shall be substituted references to the Secretary for Scotland:

(2) For the reference to the Police Act, 1890, there shall be substituted a reference to the Police (Scotland) Act, 1890: (53 and 54 Vict. c. 67).

(3) The expression "county borough" means a Royal, Parliamentary, or police burgh; and the expression "borough council" means the magistrates of the burgh; and the expression "borough fund or borough rate" means any rate within the burgh leviable by the town council equally on owners and occupiers:

(4) The provision relating to the delegation of powers shall not apply.

Application to Ireland.

9. This Act shall extend to Ireland subject to the following modifications:—

(1) For references to the Secretary of State there shall be substituted references to the Lord Lieutenant:

(2) The provisions of this Act relating to the delegation of powers shall not apply:

(3) Any of the powers conferred on the county council by this Act may be exercised by any officer of the council authorised in writing by the council in that behalf for such period and subject to such restrictions as the council think fit:

(4) In any urban district other than a county

borough and in any town the provisions of this Act shall apply as if the council of the district and the commissioners of the town, as the case may be, were a county council:

(5) The expenses incurred in the execution of this Act shall—

(*a*) in the case of the council of any county other than a county borough, be defrayed out of the poor rate and raised over so much of the county as is not included in any urban district or town;

(*b*) in the case of the council of any county borough or other urban district, be defrayed out of any rate or fund applicable to the purposes of the Public Health (Ireland) Acts, 1878 to 1907, as if incurred for those purposes;

(*c*) in the case of the commissioners of any town, be defrayed out of the rate leviable under section sixty of the Towns Improvement (Ireland) Act, 1854: provided that the limits imposed upon that rate by that section may be exceeded for the purpose of raising the expenses incurred under this Act by not more than one penny in the pound: (17 and 18 Vict. c. 103.)

(6) The expression "town" means any town as defined by the Local Government (Ireland) Act, 1898, not being an urban district: (61 and 62 Vict. c. 37.)

(7) The expressions "police area" and "chief officer of police" mean, as respects the police district of Dublin Metropolis, that district and the chief commissioner of the police for that district, and elsewhere

a police district and the county inspector of the Royal Irish Constabulary.

Short Title and Commencement.

10. This Act may be cited as the Cinematograph Act, 1909, and shall come into operation on the first day of January nineteen hundred and ten.

WHAT MAY HAPPEN UNDER THE ACT.

By the regulations which the county councils are empowered to make, Sunday shows may be prohibited by six-day licences only being granted. The local surveyor may also exercise arbitrary power in the framing of the regulations and impose all sorts of conditions as to exits, ventilation, etc. A sharp eye should be kept on these regulations by showmen in the respective counties and boroughs where their exhibitions are situate.

HOME OFFICE REGULATIONS FOR BIOSCOPE SHOWS.

REGULATIONS, dated 18th February, 1910, made by the Secretary of State under the Cinematograph Act, 1909 (9 Edw. 7, c. 30).

NEW REGULATIONS

have been issued by the Home Office under the Cinematograph Act, 1909, superseding those made in December last. The order is as follows:

1. In these regulations the word "building" shall be deemed to include any booth, tent, or similar structure.

2. No building shall be used for cinematograph or other similar exhibitions to which the Act applies unless it be provided with an adequate number of clearly-indicated exits so placed and maintained as readily to afford the audience ample means of safe egress. The seating in the building shall be so arranged as not to interfere with free access to the exits; and the gangways and the staircases, and the passages leading to the exits shall, during the presence of the public in the building, be kept clear of obstructions.

3. The cinematograph operator and all persons responsible for or employed in or in connection with the exhibition shall take all due precautions for the prevention of accidents, and shall abstain from any act whatever which tends to cause fire, and is not reasonably necessary for the purpose of the exhibition.

Fire Appliances.

4. Fire appliances adequate for the protection of the building shall be provided, and shall include at least the following—namely, a damp blanket, two buckets of water, and a bucket of dry sand. In a building used habitually for the purpose of cinematograph or other similar exhibitions, they shall also include a sufficient number of hand grenades or other portable fire extinguishers.

The fire appliances shall be so disposed that there shall be sufficient means of dealing with fire readily available for use within the enclosure. Before the commencement of each performance the cinematograph operator shall satisfy himself that the fire appliances intended for use within the enclosure are in working order, and during the performance such appliances shall be in the charge of some person specially nominated for that purpose who shall see that they are kept constantly available for use.

Enclosures.

Regulations applying in all cases and to all classes of buildings:—

5. (1) (*a*) The cinematograph apparatus shall be placed in an enclosure of substantial construction made of or lined internally with fire-resisting material

and of sufficient dimensions to allow the operator to work freely.

(*b*) The entrance to the enclosure shall be suitably placed, and shall be fitted with a self-closing, close-fitting door, constructed of fire-resisting material.

(*c*) The openings through which the necessary pipes and cables pass into the enclosure shall be sufficiently bushed.

(*d*) The openings in the front face of the enclosure shall not be larger than is necessary for effective projection, and shall not exceed two for each lantern. Each such opening shall be fitted with a screen of fire-resisting material, which can be released both inside and outside the enclosure, so that it automatically closes with a close-fitting joint.

(*e*) The door of the enclosure and all openings, bushes and joints shall be so constructed and maintained as to prevent, so far as possible, the escape of any smoke into the auditorium. If means of ventilation are provided, they shall not be allowed to communicate direct with the auditorium.

(*f*) If the enclosure is inside the auditorium, either a suitable barrier shall be placed round the enclosure at a distance of not less than two feet from it, or other effectual means shall be taken to prevent the public from coming into contact with the enclosure.

(*g*) No unauthorised person shall go into the enclosure or be allowed to be within the barrier.

(*h*) No smoking shall at any time be permitted within the barrier or enclosure.

(*i*) No inflammable article shall unnecessarily be taken into or allowed to remain in the enclosure.

Regulations applying only to specified classes of buildings :—

(2) In the case of buildings used habitually for cinematograph or other similar exhibitions, the enclosure shall be placed outside the auditorium; and in the case of permanent buildings used habitually as aforesaid, the enclosure shall also be permanent.

Provided, with regard to the foregoing requirements, that, if the licensing authority is of opinion that compliance with either or both of them is impracticable, or in the circumstances unnecessary for securing safety, and shall have stated such opinion by express words in the licence, the requirement or requirements so specified shall not apply.

Lanterns, Projectors, and Films.

6. Lanterns shall be placed on firm supports constructed of fire-resisting material, and shall be provided with a metal shutter which can be readily inserted between the source of light and the film gate.

The film-gate shall be of massive construction, and shall be provided with ample heat-radiating surface. The passage for the film shall be sufficiently narrow to prevent flame travelling upwards or downwards from the light-opening.

7. Cinematograph projectors shall be fitted with two metal film-boxes of substantial construction, and not more than fourteen inches in diameter, inside measurement, and to and from these the films shall be made to travel. The film-boxes shall be made to close in such a manner, and shall be fitted with a film-slot so constructed as to prevent the passage of flame to the interior of the box.

8. Spools shall be chain or gear-driven, and films shall be wound upon spools so that the wound film shall not at any time reach or project beyond the edges of the flanges of the spool.

9. During the exhibition all films when not in use shall be kept in closed metal boxes.

Lighting.

10. Where the general lighting of the auditorium and exits can be controlled from within the enclosure, there shall also be separate and independent means of control outside and away from the enclosure.

11. No illuminant other than electric light or limelight shall be used within the lantern.

Electric Light.

12. (*a*) Within the enclosure, the insulating material of all electric cables, including "leads" to lamps, shall be covered with fire-resisting material.

(*b*) There shall be no unnecessary slack electric cable within the enclosure. The "leads" to the cinematograph lamp shall, unless conveyed within a metal pipe or other suitable casing, be kept well apart both within and without the enclosure, and shall run so that the course of each may be readily traced.

(*c*) Cables for cinematograph lamps shall be taken as separate circuits from the source of supply and from the supply side of the main fuses in the general lighting circuit, and there shall be efficient switches and fuses inserted at the point where the supply is taken, and in addition, an efficient double-pole switch shall be fitted in the cinematograph lamp circuit inside the enclosure. When the cinematograph lamp is working, the pressure of the current across the terminals of the double-pole switch inside the enclosure shall not exceed 110 volts.

(*d*) Resistances shall be made entirely of fire-resisting material, and shall be so constructed and maintained that no coil or other part shall, at any time, become unduly heated.

All resistances, with the exception of a resistance for regulating purposes, shall be placed outside the enclosure, and, if reasonably practicable, outside the auditorium. If inside the auditorium, they shall be adequately protected by a wire guard or other efficient means of preventing accidental contact.

The operator shall satisfy himself before the commencement of each performance that all cables, leads, connections, and resistances are in proper working order. The resistances, if not under constant observation, shall be inspected at least once during each performance. If any fault is detected, current shall be immediately switched off, and shall remain switched off until the fault has been remedied.

Limelight.

13. (*a*) If limelight be used in the lantern the gas cylinders shall be tested and filled in conformity with the requirements set out in the Appendix hereto. The tubing shall be of sufficient strength to resist pressure from without, and shall be properly connected up.

(*b*) No gas shall be stored or used save in containers constructed in accordance with the requirements contained in the appendix.

Licences.

14. Every licence granted under the Act shall contain specific conditions for the carrying out of Regulations 2 and 5 (1) (*a*), (*b*), (*c*), (*d*), (*e*), (*f*) in the building for which the licence is granted, and may, in accordance with Regulation 5 (2), contain an expression of opinion on the matters referred to in the proviso thereto.

15. Subject to the provisions of No. 16 of these Regulations, every licence granted under the Act shall contain a clause providing for its lapse, or, alternatively, for its revocation by the licensing authority, if any alteration is made in the building or the enclosure without the sanction of the said authority.

16. Where a licence has been granted under the Act in respect of a moveable building, a plan and description of the building, certified with the approval of the licensing authority, shall be attached to the licence. Such a licence may provide that any of the conditions or restrictions contained therein may be modified either by the licensing authority or by the licensing authority of the district where an exhibition is about to be given. The licence and plan and description or any of them shall be produced on demand to any police constable, or to any person authorised by the licensing authority, or by the authority in whose district the building is being or is about to be used for the purpose of an exhibition.

17. The Regulations dated December 20, 1909, made under the Cinematograph Act, 1909, are hereby repealed, provided, nevertheless, that any licence granted prior to such repeal shall remain valid for the period for which it was granted without the imposition of any more stringent condition than may have been imposed at the time of the grant.

Given under my hand at Whitehall this eighteenth day of February, 1910.

H. J. Gladstone,
One of His Majesty's Principal
Secretaries of State.

THE ACT OF 1751.

This Act, which is entitled "An Act for the Better Preventing Thefts and Robberies and for Regulating Places of Public Entertainment and Punishing Persons Keeping Disorderly Houses," was passed in the reign of George II., and was rendered necessary owing to gangs of young sparks about town frequenting such places as the famous Vauxhall Gardens and the like, and carrying on high jinks.

It provides that "Any house, room, garden, or other public entertainment of the kind in the cities of London and Westminster, or within 20 miles therefrom, without a licence for that purpose from the Michaelmas Quarter Sessions, shall be deemed a disorderly house."

Power is given under the Act to any constable or other person authorised by any justice to enter such place and *seize every person found therein* in order that they may be dealt with according to law, and every person keeping such house, room, garden, or other place without a licence should forfeit the sum of £100 to *such person as will sue for the same*, and to be otherwise punishable as the law directs in cases of disorderly houses.

No such place, *although licensed*, is to be open for any of the said purposes *before the hour of five in the afternoon.*

The provisions of the Act are not to apply to the Theatres Royal, Drury Lane, and Covent Garden, or the Haymarket, or to any places carried on by virtue of Letters Patent or Licence of the Crown, or the Licence of the Lord Chamberlain of His Majesty's household.

On any two persons giving notice in writing to any constable of any place conducted without a licence, and upon sworn information to that effect, the informers enter into a recognisance to prosecute at the Quarter Sessions or Assizes, a prosecution to be instituted.

The person having the management of any such house shall be deemed to be the keeper thereof, and shall be liable to prosecution and punishment.

An indictment cannot be removed to any other court than the Assize or Quarter Sessional Court, and must be heard, tried, and *finally* determined at those courts.

NOTE.

It will be seen that this Act does not apply to the provinces or to any place more than 20 miles distant from London.

THE CHILDREN ACT, 1908.

The Children Act, 1908, 8 Edw. 7, ch. 67, contains provisions for the safety of children at entertainments which are of importance. By section 121 of that Act it is enacted:

Safety of Children at Entertainments.

(1) Where an entertainment for children, or any entertainment at which the majority of persons attending are children is provided, and the number of children who attend the entertainment exceeds 100, and access to any part of the building in which children are accommodated is by stairs, it shall be the duty of the person who provides the entertainment to station and keep stationed wherever necessary a sufficient number of adult attendants, properly instructed as to their duties, to prevent more children or other persons being admitted to any such part of the building than that part can properly accommodate, and to control the movement of the children or other persons admitted to any such part whilst entering and leaving, and to take all other reasonable precautions for the safety of the children.

(2) Where the occupier of a building permits, for hire or reward, the building to be used for the purpose of an entertainment, he shall take all reasonable steps

to secure the observance of the provisions of this section.

(3) If any person, on whom any obligation is imposed by this section, fails to fulfil that obligation, he shall be liable, on summary conviction, to a fine not exceeding, in the case of a first offence, £50, and in the case of a second or subsequent offence, £100, and also, if the building in which the entertainment is given is licensed under any of the enactments relating to the licensing of theatres and of houses and other places for music and dancing, the licence shall be liable to be revoked by the authority by which the licence was granted.

(4) A constable may enter any building in which he has reason to believe that such an entertainment as aforesaid is being, or is about to be, provided with a view to seeing whether the provisions of this section are carried into effect.

(5) It shall be the duty of the council of the county or county borough in which a building in which any contravention of the provisions of this section is alleged to have taken place to institute proceedings under this section if the building is a building licensed by the Lord Chamberlain, or is licensed by the council of the county or county borough under the enactments relating to the licensing of theatres or of houses and other places for music or dancing, and in any other case it shall be the duty of the police authority to institute such proceedings.

(6) This section shall not apply to any entertainment given in a private dwelling-house.

THE VACUITY OF THIS ACT.

This Act, like many other Acts of Parliament dealing with technical subjects, gives evidence of the lack of knowledge on the vital points possessed by its framers. It will be seen that it is incumbent upon promoters of entertainments coming within the scope of the Act—which, be it remarked, applies to the United Kingdom as a whole—to provide a *sufficient number of adult attendants*. Opinions upon what constitutes a sufficient number, like the poles, will be wide apart. It would have undoubtedly been better had a fixed number of attendants per 100 or 250 children been stated, as showmen would then have known where they stood.

It would also appear that where the use of a building is granted *free* for any entertainment, the occupier has no responsibility cast upon him to take all reasonable steps for the observance of the section, the Act distinctly specifying that it is only where the building is permitted to be used for hire or reward.

The Act would also appear not to apply to any building where access to any part in which children are accommodated is not by stairs.

Private dwellings in which an entertainment is given are exempt.

TABLES FOR BIOSCOPE OPERATORS

TABLE OF DISTANCES FOR LANTERN SCREENS.

To find the largest screen possible to use in given room with lens of certain focal length: Subtract the focal length of lens from the distance between the screen and the lens; multiply by width of slide, and divide by the focal length of the lens.

Distance between Lantern and Screen.	Focus of Lens. 4 in.		6 in.		8 in.		10 in.		12 in.		14 in.	
	Diameter of Picture (obtained with 3 in. circle).											
Feet.	FT.	IN.	FT.	IN.	FT.	IN.	FT.	IN.	FT.	IN.	FT.	IN.
10 ...	7	6	5	0	3	9	3	0	2	6	2	2
12 ...	9	0	6	0	4	6	3	7	3	0	2	7
15 ...	11	3	7	6	5	8	4	6	3	9	3	3
20 ...	15	0	10	0	7	6	6	0	5	0	4	3
25 ...	18	9	12	6	9	4	7	6	6	3	5	4
30 ...	22	6	15	0	11	3	9	0	7	6	6	5
35 ...	26	3	17	6	13	1	10	6	9	9	7	6
40 ...	30	0	20	0	15	0	12	0	10	0	8	6
45 ...	33	9	22	6	16	10	13	6	11	3	9	8
50 ...	37	6	25	0	18	9	15	0	12	6	10	9
60 ...	45	0	30	0	22	6	18	0	15	0	12	11
70 ...	52	6	35	0	26	3	21	0	17	6	15	1
80 ...	60	0	40	0	30	0	24	0	20	0	17	3
90 ...	67	6	45	0	33	9	27	0	22	6	19	5
100 ...	75	0	50	0	37	6	30	0	25	0	21	7

TABLE OF DISTANCES FOR CINEMATOGRAPH LENSES.

To find the largest screen possible to use in given room with lens of certain focal length:—Divide the distance from the screen by the focal length of lens. Result will be size of picture in feet.

Distance between Lantern and Screen.	Focus of Lens. 2 in.		$2\frac{1}{2}$ in.		3 in.		$3\frac{1}{2}$ in.		4 in.		5 in.	
	Diameter of Picture (obtained with 1-in. mask).											
FT.	FT.	IN.	T.	IN.	FT.	.	FT.	IN.	FT.	IN.	FT.	IN.
10	5	0	4	0	3	4	3	0	2	6	2	0
12	6	0	4	9	4	0	3	6	3	0	2	6
15	7	6	6	0	5	0	4	6	3	9	3	0
20	10	0	8	0	6	8	5	8	5	0	4	0
25	12	6	10	0	8	4	7	2	6	3	5	0
30	15	0	12	0	10	0	8	6	7	6	6	0
35	17	6	14	0	11	8	10	0	8	9	7	0
40	20	0	16	0	13	4	11	6	10	9	8	0
45	22	6	18	0	15	0	13	0	11	3	9	0
50	25	0	20	0	16	8	14	3	12	6	10	0
60	30	0	24	0	20	0	17	0	15	0	12	0
75	37	6	30	0	25	0	21	6	18	9	15	0
100	50	0	40	0	33	4	22	0	25	0	20	0

TABLE OF STANDARD SIZED CARBONS.

FOR USE WITH CONTINUOUS CURRENT.

Current in Amperes.	Lower Carbon. Solid.	Top Carbon. Cored.
10 to 15	10 m/m	13 m/m
15 to 25	12 m/m	16 m/m
25 to 35	13 m/m	18 m/m
30 to 45	14 m/m	20 m/m
40 to 50	16 m/m	22 m/m
50 to 70	18 m/m	25 m/m

FOR USE WITH ALTERNATING CURRENT.

Top and bottom Carbons are same size and both are cored

20 to 30	13 m/m
30 to 45	16 m/m
35 to 50	18 m/m
50 to 60	20 m/m
60 to 75	22 m/m
80 to 100	25 m/m

CARRYING CAPACITIES OF WIRES AND CABLES.

Size S.W.G.	Carrying capacity at 1000 amps. per sq. in. density.	
1/16	3.2	Amps.
7/22	4.3	"
7/20	7.1	"
7/18	12.6	"
7/16	22.2	"
7/14	35.0	"
19/16	60.0	"
19/14	94.5	"

LIMELIGHT TABLES.

TO FIND AMOUNT OF GAS IN CYLINDERS.

Pressure as indicated on Gauge, in terms of Atmospheres.	Size of Cylinder, in Cubic Feet Capacity.					
	6	10	12	15	20	40
20	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	0
40	2	$3\frac{1}{4}$	4	5	$6\frac{1}{4}$	$12\frac{1}{2}$
60	3	5	6	$7\frac{1}{2}$	10	20
80	4	$6\frac{1}{2}$	8	10	$12\frac{1}{2}$	25
100	5	$8\frac{1}{2}$	10	$12\frac{1}{2}$	$16\frac{1}{2}$	33
120	6	10	12	15	20	40

The next table shows the quantities of oxygen and coal gas consumed per hour by blow-through, injector, and mixed jets. Should hydrogen be used in place of coal gas, twice the quantity of hydrogen will be required; the light obtained will be slightly better.

Type of Jet.	Oxygen Gas.	Coal Gas.	Candle-power.
Blow-through ..	5 ft.	6 ft.	400- 600
Injector Jet ...	5 ft.	6 ft.	1,000-1,200
Medium Power Mixed Jet	5 ft.	6 ft.	1,000-1,200
High Power Injector Jet ...	10 ft.	12 ft.	1,600-2,000
High Power Mixed Jet	10 ft.	12 ft.	1,600-2,000

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