Making adjustments and oiling parts of sound equipment.

# Feeding the Film by Intermittent Action in Motion Picture Cameras

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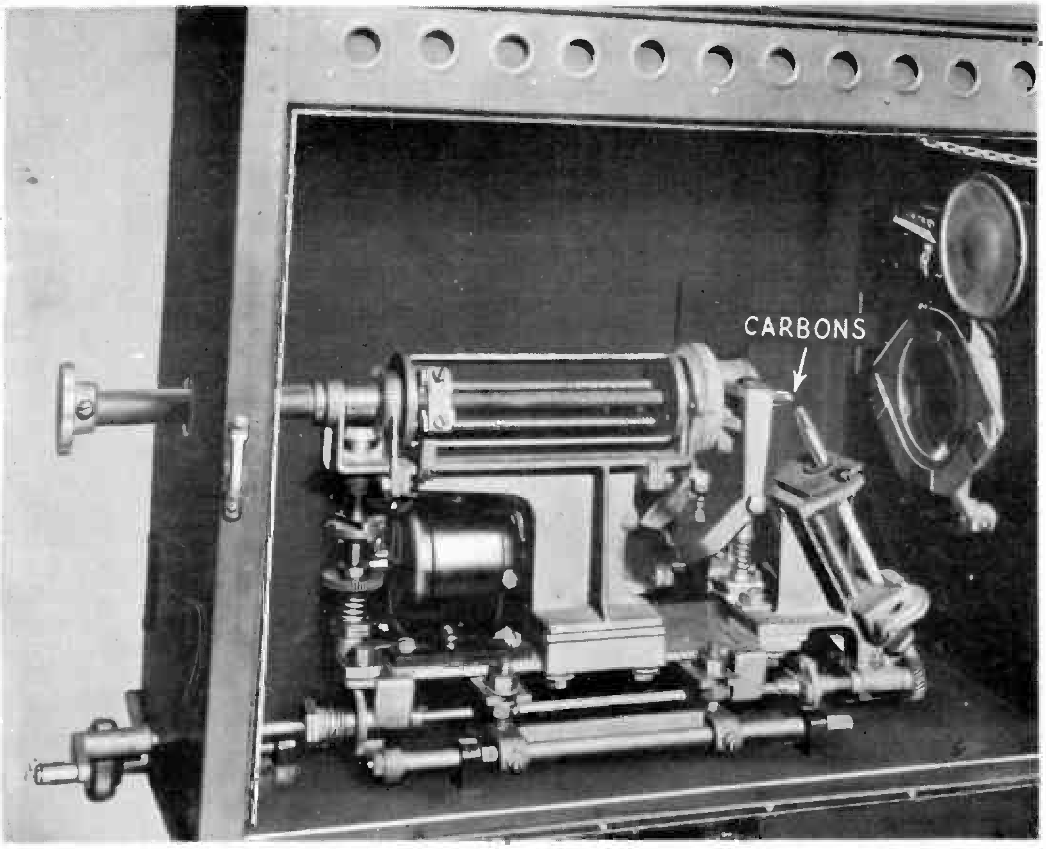


*When in operation a brilliant flame is produced at the two carbons of an arc lamp.*

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## FEEDING THE FILM IS BY INTERMITTENT ACTION IN MOTION PICTURE CAMERAS.

In the days when only silent motion pictures were shown the requirements for projection were not quite as rigorous as they are at the present time due to the introduction of sound along with the picture. This applies particularly to film speed, which averaged sixteen pictures per second for silent projection. It is to be understood, however, that by means of a special variable speed mechanism on the projector the film could be run as fast as thirty pictures per second.

When sound effects accompany a picture it is necessary to run the film at the same speed as that at which it was recorded, if the tone quality and tempo of the speech and music are to be the same as that of the original. Otherwise we would possibly hear a distorting effect which would be quite unnatural. From considerations of sound frequencies it was considered best practice to operate the film at a speed of ninety feet a minute. This is equivalent to twenty-four "still" pictures being flashed in succession on the screen each second. These separate pictures appear to the eye as a single moving picture due to the faculty of persistence of vision.

### THE PROJECTOR

In Figure 1 is shown a complete Simplex projector with high intensity carbon lamp equipment. This type is used quite extensively in the sound motion picture field. The projector consists of three main parts as follows: (A) the lamphouse which contains the carbon arc mechanism that supplies the light for projection of the picture, (B) the "picture head" that contains the lens and the mechanism for moving the film into place before the light beam, and (C) the pedestal that supports and furnishes the means for tilting the lamphouse and picture head equipment so that the beam of light may be accurately placed on the screen.

The first part of our study will deal with the subject mentioned in the foregoing paragraph under (A), or the lamphouse and its associated equipment that produces the brilliant light source which is focused on the film as it passes through the sound head.

### SOURCE OF LIGHT

The carbon arc has been found by experience to furnish the best supply of light in the large quantities so necessary in motion picture projection. The great light-giving property of a carbon arc is due to the fact that carbon will not melt or vaporize unless subjected to a temperature of a very high order. For example, when a pure carbon arc is in operation the temperature of the "crater" is maintained at over 3,700 degrees Centigrade. Figure 2 shows a carbon arc in operation consisting of two carbons, marked "A" and "B" and known respectively as "positive" and "negative" carbons. Notice that the "crater" is located at the point marked "A" on the positive carbon. While the positive carbon "A" is burned away in a "crater" or hollowed out form, the negative carbon "B" burns away in pointed form. It is the "crater" of the positive carbon that produces the greatest source of light and for that reason you

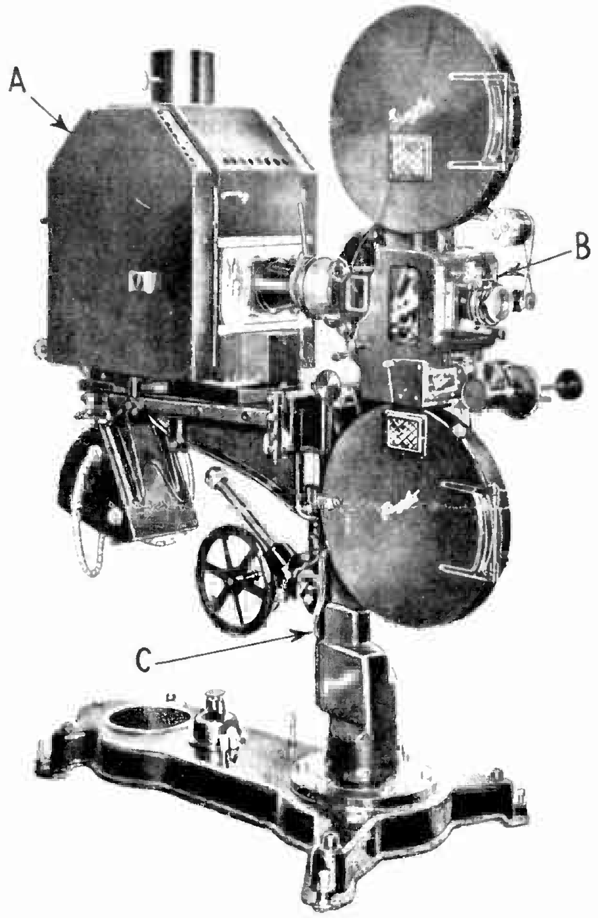


FIG. 1 — A COMPLETE SIMPLEX PROJECTOR.

will find all lamphouses which are not of the reflector type so designed that the crater of the positive carbon is kept pointed toward the lens that focuses the light on the film.

The relative positions of the carbons and the lens are seen in Figure 3, where "A" indicates the lens, which is known as a condenser lens, while "B" shows the position of the arc directly in front of the lens. Although Figure 4 illustrates the appearance of two halves of a condenser lens, it is to be understood that in many machines only one of these halves is used.

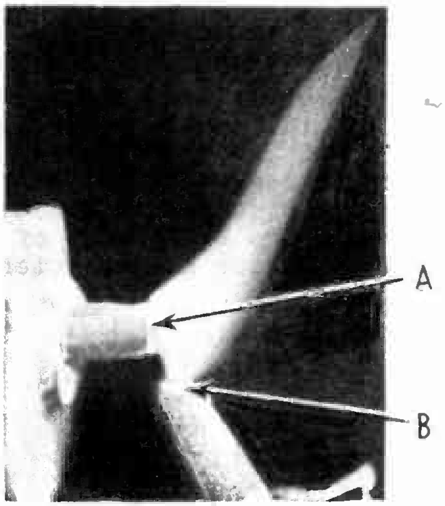


FIG. 2 A CARBON ARC IN OPERATION.

The name "condenser lens" is given to this type because it gathers a considerable amount of light and condenses it to a small spot of great brilliance on the film aperture. In Figure 5 is seen a graphic illustration of how a condenser lens "gathers" a large number of light rays and focuses them to a small and very bright spot of light on the picture aperture projection.

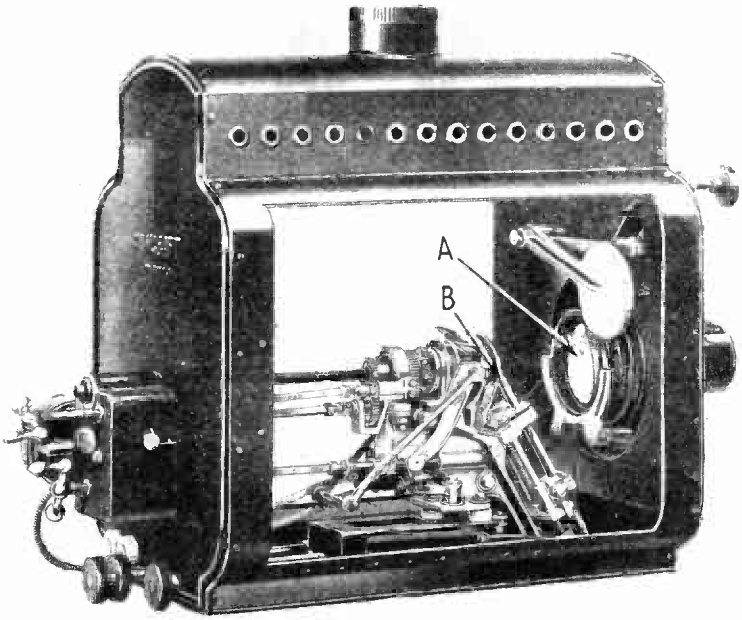


FIG. 3 — SHOWING RELATIVE POSITIONS OF CARBONS AND LENS.

The brilliancy of the crater in a pure carbon arc is of the order of 160 candle power for every square millimeter. One millimeter is equal to 1/100th of a meter, and a meter is equal approximately to 39.37 inches. Knowing that this degree of brilliancy was the upper limit that could be obtained by vaporizing a solid substance, such as carbon for example, an investigation was made of vapors and gases in a search for more efficient light sources. It was found that if a pure carbon rod used to produce the positive crater were replaced by a carbon which was cored or drilled through from end to end and filled with a chemical material that produces gas when heated, a brilliancy of from 500 to 900 candle power per square millimeter could be obtained and, of course, this is considerably greater than the 160 c.p. of an ordinary solid carbon positive. The only other source of light that exceeds the brilliancy of this new high intensity arc is the noon-day sun which has an intensity of about 920 candle power per sq. mm.

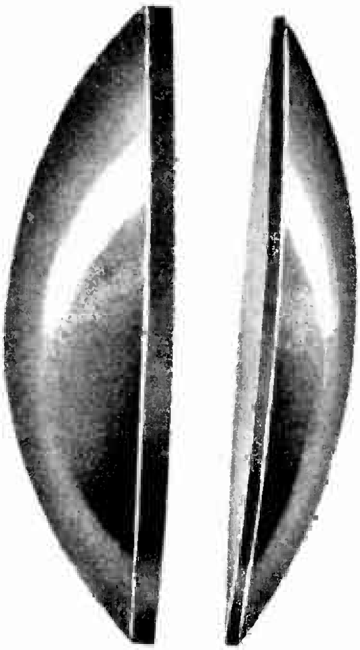

FIG. 4 — TWO HALVES OF A CONDENSER LENS.

Figure 6 shows how the gas from a cored negative carbon strikes the crater of the cored positive carbon and by keeping a certain amount of the gas from leaving the positive crater causes it to become even more brilliant. It is understood, of course, that the heating of the arc is caused by electric current. In operation the current is turned on by means of the arc switch seen under the lamphouse in Figure 1, the carbons are then caused to touch each other for a fraction of a second and then to be drawn quickly apart. At the instant of contact the current surges from the positive to the negative carbon and the carbon melts and vaporizes because the resistance of the path to the current is very high where the carbons come together. When the carbons are drawn apart the carbon vapor furnishes a path of comparatively high resistance to the current which travels through it to the negative carbon and as long as current flows the vapor is kept heated to incandescence. If the gap between the two carbons becomes too wide the vapor will in turn become very thin causing the resistance of the vapor path to increase to such an extent that the current will cease to flow and the arc will be extinguished or, as we say, the arc will "go out". To start the arc going again the carbons must first be brought together and then drawn apart as just explained.

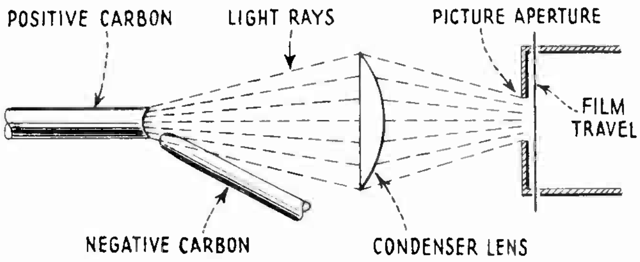


FIG. 5 — LIGHT RAYS ARE CONCENTRATED BY A CONDENSER LENS.

It is evident that inasmuch as the carbons continue to burn away slowly during normal operation the gap separating them will increase in width and in time the gap will become so long that the current cannot travel across it and eventually the arc will "go out". In the early days of the motion picture industry the mechanism by which the carbons were "fed" together was operated by hand which

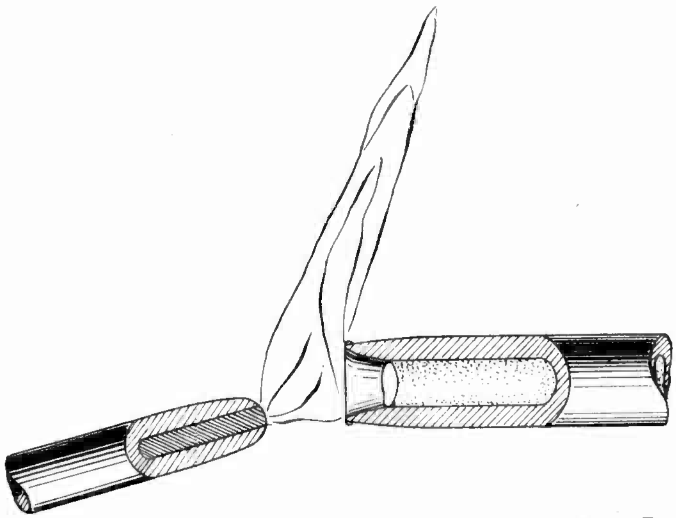

FIG. 6—FLAME PRODUCED FROM CARBONS WHICH ARE CORED

meant that a sharp watch had to be kept on the adjustment by the projectionist lest he "lose his arc" during the running of the film. In modern lamphouse construction, however, this feeding of the carbons is done automatically by means of an electric motor geared to the carbons holders. When the gap between the carbons becomes a certain predetermined length the motor starts up and moves the carbons together slowly until the proper distance between them is obtained at which time the motor stops. This operation is repeated again and again as the carbons burn away to the point where the mechanism has reached the limit of its motion and cannot further bring the shortened pieces of carbon together for the proper gap distance.

In Figure 7 is seen another type of lamphouse in which both carbons are mounted horizontally with a reflector used to collect the rays of light in back of the arc and transfer them to the condenser lens, where these reflected rays join the direct rays of light from the arc, thus increasing the total amount of light passing to the condenser lens to be focused on the picture aperture. Referring to the photograph, "A" indicates the position of the arc proper where the two carbons are brought together, "B" is the parabolic reflector, and "C" the condenser lens. In this particular case you will note from the illustration that the positive (thick) carbon is at

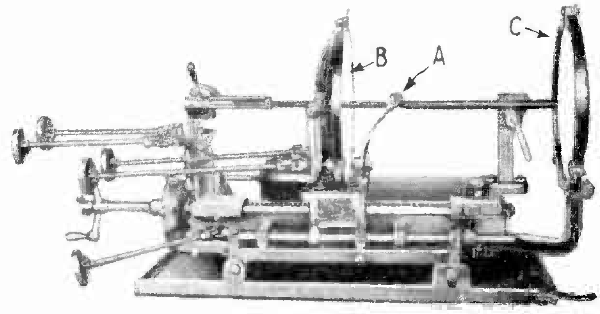


FIG. 7—THE CARBONS HERE ARE MOUNTED HORIZONTALLY.

the right nearest the condenser lens instead of at the left or furthest side from the lens. With this relative position of the carbons in the lamphouses, without a reflector, it would be necessary to have the crater of the positive carbon pointed at the condenser lens so that the greatest number of light rays would strike the lens and be focused to a "spot" on the aperture. However, in

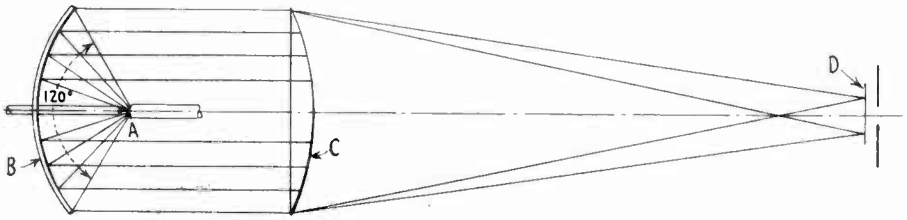


FIG. 8 THE COURSE TAKEN BY LIGHT RAYS.

the type of lamp we are now studying, called the Reflector Arc Lamp, instead of causing the rays of light from the crater to strike directly on the condenser lens, the crater is pointed towards the reflector which gathers the light rays and reflects them to the condenser lens. By this method the light rays from the positive carbon crater of the arc are sent through the condenser to be focused on the aperture.

FOCUSING THE LIGHT

Figure 8 shows the course of light rays as they travel from the arc to the reflector, thence to the condenser lens and finally to the aperture. The arc crater of the positive carbon is shown at

"A", the parabolic reflector at "B", and the condenser lens at "C". The aperture of the picture head on the projector is shown at "D" and it can be seen that all the light collected by the reflector and condenser lens is focused to a spot just large enough to "cover" the aperture, which is the size and shape of one picture or "frame" of the film. It is quite important that this "spot" be of sufficient size to cover the aperture for if it is too large, light will be wasted and if too small the edges of the picture on the screen will not be illuminated.

Figure 9 demonstrates three conditions of the "spot" on the aperture. In these three conditions the black oblong represents the aperture past which the film moves during the course of projection, the aperture being only slightly smaller than a single picture or "frame" of film. The circle around each black oblong area represents the size of the spot of light which can be focused by the condenser lens on the aperture. Spot "A" wastes 81% of the light since only 19% can pass through the aperture, the rest being thrown on the "cooling plate" of the picture head. Spot "B" is a spot of practical size but even in this case 57% of the light is lost on the cooling plate. However, this waste cannot be overcome due to

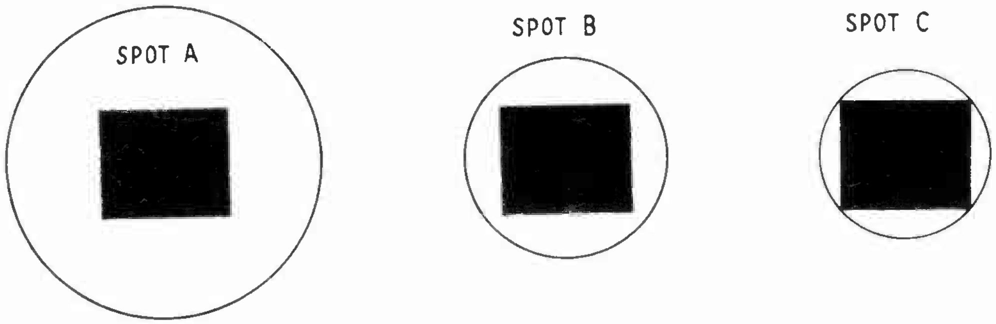


FIG. 9—RELATION BETWEEN SIZE OF SPOT OF LIGHT AND APERTURE OPENING.

the fact that bringing the spot to a smaller diameter as in spot "C" is liable to cause dark corners to appear in the picture on the screen, and also color fringes may show due to "chromatic aberration" caused by the condenser lens. We shall learn more about the term "aberration" under the subject of "lenses". As can be seen by the three illustrations most of the light loss is due to the fact that the spot of light is round and the aperture is oblong. If it were possible to have a combination where both the spot of light and the aperture were oblong it is obvious that a much higher efficiency could be expected from the arc system.

## THE ARC CONTROLS

There are two main controls used in arc lamp equipment of the reflectorless type, shown in Figure 3. First is the mechanism which moves the arc back and forth in relation to the condenser lens and which governs the size of the spot on the aperture, and second, the "arc striking" mechanism which is used to bring the two carbons together and quickly draw them apart. We have learned that this operation is necessary to start the arc and is known as "striking the arc". After this operation has been completed the "automatic feed" mechanism comes into play to maintain the proper distance between the carbons. Means for additional adjustments are provided allowing the arc to be accurately centered in front of the condenser lens.

In this type of lamphouse a "pinhole" is provided in the casing so that an enlarged image of the arc crater is thrown on the wall of the projection booth enabling the operator to see the condition of the arc at all times. This is a practical application of the principle of the pinhole camera.

The Reflector type lamp has two adjustments which are not provided in the non-reflector type. These adjustments are used to tilt the reflector up and down and sidewise so that the rays of light it collects will be reflected without loss to the condenser lens. Again referring to Figure 7 and noting the knobs at the left of the lamp, the upper two are used to center the negative carbon on the

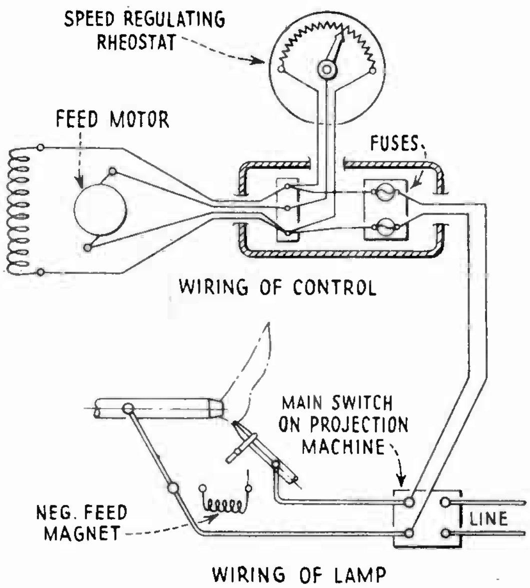


FIG. 10—CIRCUIT THAT CONTROLS SPEED OF MOTOR.

positive carbon which is held rigid, the next two knobs down are for reflector tilting, the next handle down is the arc striking bar, and the lower knob moves the whole assembly back and forth in relation to the condenser lens thus allowing for focusing of the correct size spot on the aperture.

The automatic feeding of the arc is accomplished by using a small motor which is geared to the carbon holders so that as the motor runs the carbons are slowly moved together. A schematic diagram of the circuit that controls the speed of the motor is shown in Figure 10. It will be seen that one side of the line connects to the positive (thick) carbon while the other side connects to the negative (thin) carbon. Two wires lead from the main switch on the projection machine to the motor and rheostat.

The theory of operation is that when the gap between the carbons is small it is comparatively easy for the current to pass across



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the gap over the carbon vapor path but as the carbons burn away and the gap widens it takes more voltage to force the current across the gap. When this greater voltage is on the arc it also affects the armature of the feed motor causing it to speed up, thus feeding the carbons together faster. When the gap is thus shortened the voltage returns to normal and the motor slows down so that the feeding of the carbons is also slowed down back to the normal rate once more.

Figure 11 shows a widely used make of lamp that eliminates the condenser lens by causing the arc crater to be focused on the picture aperture by the reflecting mirror. It is known as the Strong lamp and is made by the Strong Electric Corporation. In Figure 11 this lamp is shown with the reflector swung out of operating position for inspection. The path of light rays in a lamp using both reflector and condenser lens was shown in Figure 8.

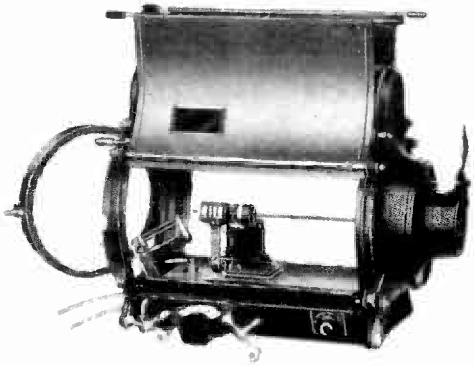

FIG. 11— MECHANISM OF A "STRONG" LAMP.

Figure 12 is a sketch showing the path of rays from arc to aperture when only a reflector is used. This path is shown by the solid lines. The dotted lines indicate the path of rays when it is desired to use the arc for projecting lantern slides. By moving the reflecting mirror forward the light rays are caused to leave the reflector in straight horizontal lines instead of converging to a small spot at the picture aperture. By swinging a small condenser lens into place a portion of these parallel rays are picked up and converged so that after passing through a lantern slide they enter the projection lens. This lens as we shall see later projects the image to a sharp focus on the screen.

To sum up the various points about the arc lamp: It is a brilliant source of light by means of which the picture is projected to the screen on the stage after passing through various lens combinations. The arc is started into operation first by throwing the "table switch" under the lamphouse to the operating position and second by bringing the carbons together and separating them slightly by means of the "arc striking" handle. From this point on the arc control motor goes into action and separates the carbons to provide the proper gap distance between them. If the necessary adjustments of the reflector and arc position mechanisms have been previously made, the light from the arc will be focused to an intense spot just covering the aperture. The "douser" (a metal plate placed on the lamphouse between the aperture and the condenser lens opening which cuts off the light from the aperture and confines it to the lamphouse) is then closed. We are now ready to proceed to the study of the picture head through which the light passes on its way to the screen.

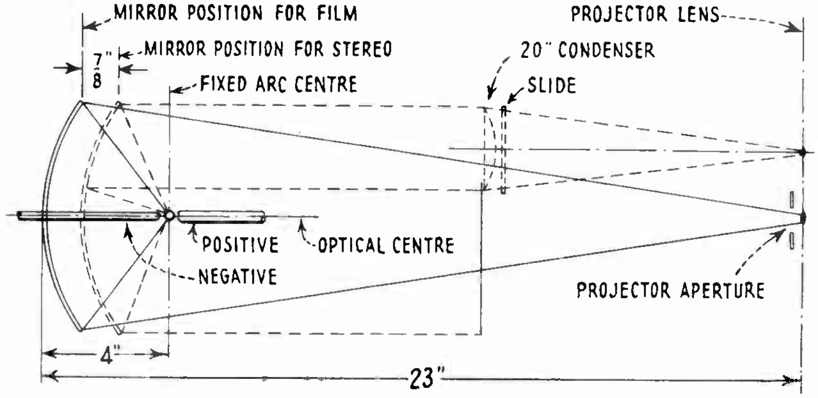


FIG. 12—**PATH OF LIGHT RAYS FROM ARC TO APERTURE.**

## TYPES OF PROJECTORS

There are several manufacturers of picture projection head equipment and in some cases different models are made by the same company. For instance, the International Projector Corporation has two models which are in wide use, namely, the Standard Simplex and the Super-Simplex. The Enterprise Optical Company manufacturers a picture head which is known as the Motiograph. This company also makes a complete sound motion picture projector in which the picture head, sound head, lamp, and base are all made into a single unit. This method is different from the usual procedure because other leading companies in the field make only the picture projection equipment with provisions for adapting the sound projection apparatus to their motion picture machines.

## OPERATION OF THE PROJECTOR

We will study the Powers projector first, not because it is in wider use than either the Simplex or Motiograph machines, but its open-type mechanism permits a clearer explanation and illustration of the principles of motion picture projection and the action taking place during each step in the progress of the film through the picture head.

Figure 13 is a photograph of the complete Powers projector including lamphouse, picture head, upper and lower magazines, pedestal, and motor drive. "A" shows the maximum angle at which the machine can be set. It is necessary to vary the angle of tilt in different theatres according to the height of the projection booth in relation to the screen, this slope being known as the "projection angle". "B" shows two handles for controlling the "douser". In all cases where two handles are provided for controlling a piece of mechanism it is only done to make operation easy from either side of the machine.

The parts are identified as follows: "C" is a condenser lens spacing used to space the two halves of the condenser lens to obtain the best focus of the "spot" on the aperture; "D" is the ruby glass eye shield which keeps the glare of the spot out of the projectionist's eyes; "E" is a film footage counter that tells how much film has been run off; "F" focuses the image sharply on the screen; "G" is a speed control for the motor; "H" is the speed control adjustment; "K" is the motor switch which starts the machine; "L" is the "table switch" for starting the arc; "M" indicates the upper and lower magazines; "O" is a hand wheel for changing the projection angle; "P" is used to lock the angular adjustment, and "R" is the motor. The machine as it is shown in Figure 13 is used for projecting silent pictures. When adapted to sound projection a "sound head" is installed between the picture head and the lower magazine

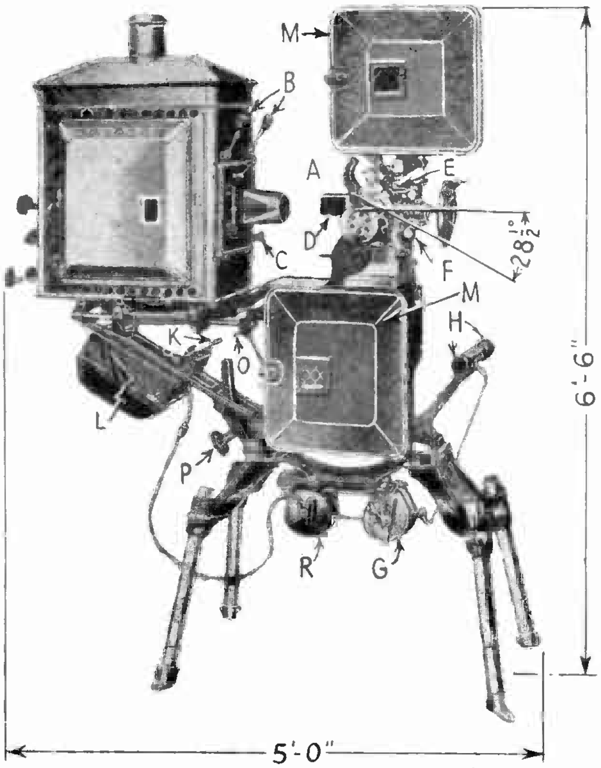


FIG. 13—VIEW OF A COMPLETE POWERS PROJECTOR.

as will be seen later. Figure 14 shows the picture head with part of the upper and lower reels included.

By comparing Figure 14 with Figure 15, which shows the same picture with film threaded into place ready for operation, you will be able to follow the action which takes place in the picture head at each important point in the course of the film's journey through it as we will now explain. Starting from the top magazine where a full reel of film is in place the film passes down through two steel rollers which press snugly against each side of the film. This is called the "fire trap" and should the film catch fire its purpose is to prevent the flame from getting into the upper magazine and setting fire to the upper reel of film. From the fire trap rollers the film passes to the upper feed sprocket "A" the sprocket holes in the film being held in place on the sprocket teeth by "roller" "B". The film then passes down through the "picture gate" "J" shown open in Figure 14 and closed in Figure 15. The picture gate contains the aperture through which the arc light passes on its way to the screen. The film is held snugly in place as it passes through the gate by the "film guide roller" "K" and the spring strips, known as tension shoes, which are shown on each side of the aperture in Figure 14. It is understood that when the film is passing down in front of the aperture and the light of the arc is focused on the aperture the image of the picture will be produced on the screen providing the lens is in proper adjustment. The purpose of the feed sprocket "A", as we have seen, is to draw the film down from the

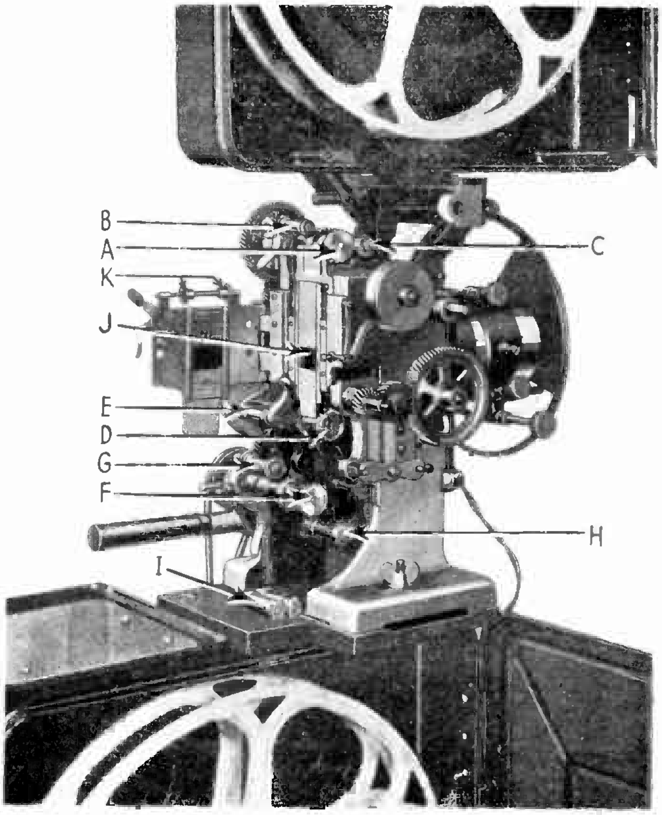


FIG. 14 — CLOSE-UP VIEW OF POWERS PROJECTOR.

upper reel and feed it to the picture gate. In order that the film may then be passed through the picture gate in such a manner that each picture or frame on the film will be at rest for a fraction of a second in the aperture before it is moved on, a toothed wheel called the "intermittent sprocket" comes into play. This sprocket is shown "D" where the film is being held in place over its teeth by the small roller "E" shown in the opened-out view of the picture gate in Figure 14. The intermittent sprocket works in short jerks, that is, it pulls the film down approximately three-quarters of an inch (one picture or frame) and rests a fraction of a second, pulls the film down another "frame" and waits, repeating this operation at the rate of 24 pictures per second.

The film is prevented from moving, due to its inertia, after the intermittent sprocket stops, by the friction in the picture gate. Tension shoes must be adjusted for the proper pressure to produce just enough drag or friction, but not too much,as otherwise the sprocket holes would be torn by the intermittent sprocket in short time, and the sprocket teeth would wear out prematurely. The light of the arc, therefore, is passing through 24 separate and distinct pictures and projecting 24 images on the screen every second while the machine is in operation. We have already explained that when the eye sees this number of pictures per second on a screen and each picture is slightly different from the other and in proper sequence, our persistence of vision produces the illusion of motion pictures.

After passing through the picture gate and intermittent sprocket, the film forms a loop around a roller called the "loop setter" marked "H" (this roller is not used for sound picture projection with certain types of sound heads,) and from there it continues on to a sprocket wheel "F" which feeds the film at a steady rate of speed to the lower reel. Roller "G" holds the film snugly against sprocket "F" causing the sprocket holes in the film to mesh with the

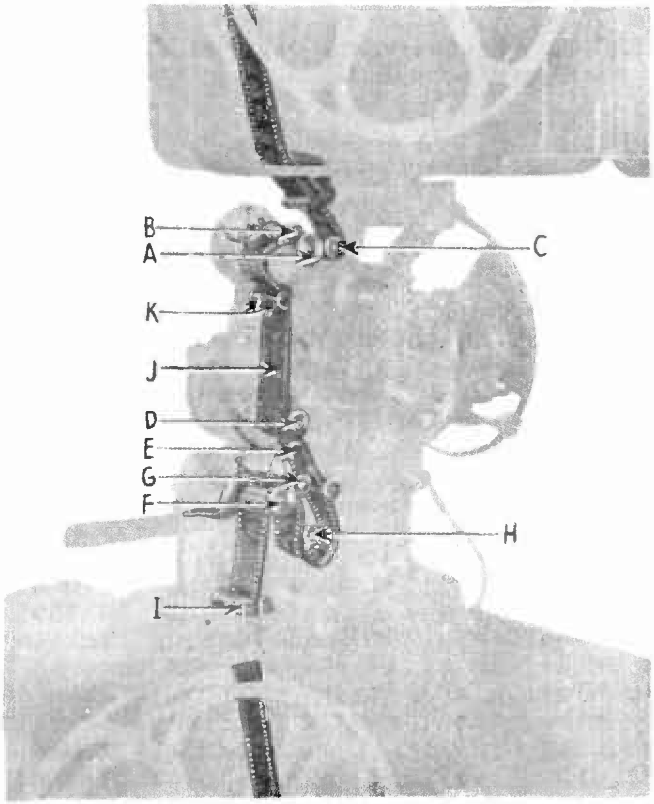


FIG. 15—A FILM THREADED IN PLACE.

sprocket teeth. You will see that the lower magazine is also supplied with a fire trap "I" similar to the one in the upper magazine.

THE INTERMITTENT MOVEMENT

Although the intermittent sprocket "D" pulls the film the same number of feet per minute through the picture gate, we know from our study of the action of the intermittent sprocket that this pull is not uniform but intermittent in action. That is, it pulls one frame or picture into place in front of the aperture, allows it to rest there for a fraction of a second and then quickly pulls that picture down out of the aperture and replaces it with the next picture on the film. This operation takes place at the rate of 24 pictures per second which allows the machine to project 24 "still" pictures on the screen every second. Since 24 pictures per second are fed to the picture gate by the upper sprocket it can be seen that the intermittent must move very quickly in order to pull the same number of "frames" per second through the gate intermittently and allow each picture to rest for a short time in the aperture.

The intermittent sprocket moves five times as fast as either the upper or lower sprockets which means that it passes the same amount of film in one-fifth the time. If the loops were not provided there would be no spare film to draw on and the intermittent would tear out the sprocket holes in its quick downward motion. The upper feed sprocket keeps a supply of film in the loop for the intermittent to draw upon and the intermittent takes it up in jerks and feeds it to the lower loop from which it is taken away by the lower feed sprocket. It should be borne in mind, however, that all the sprockets pass the same amount of film per second which figured from 90 feet per minute is one and a half feet per second.

THE TAKE-UP REELS

Before passing on to a detailed examination of the Powers intermittent movement we will discuss the mechanism that allows the lower or "take-up" reel to take up the film as it comes from the upper feed sprocket. The upper reel has no driving power other than the pull of the film as it is drawn down through the fire gate by the upper feed sprocket "A" in Figure 15. This causes the reel to revolve and as the reel is locked on the shaft in the magazine the shaft also revolves. The shaft has a simple spring friction mechanism located on the outside of the magazine, that gives a slight resistance to its turning and thus prevents the shaft from continuing rotation should the machine stop for any reason. If this friction were not provided there would be a tendency for the reel to continue revolving even after the pull on the film had ceased, causing the reel to unwind several layers into the magazine.

The lower reel must be provided with a driving mechanism of such design that it will take up the film fed to it by the lower feed sprocket under all conditions. You can easily realize that the lower reel cannot be driven at constant speed because it winds more film during one revolution when it is full than when nearly empty due to the greater circumference of a full reel of film. For instance, when the machine is starting to project a new reel most of the film is on the upper reel and only a few turns are on the lower reel. The diameter of the "pulling circle" of the film in this case is little more than the hub diameter of the reel itself but as the machine continues to run and more film is wound on the lower reel its diameter increases until at the end of the run it is about twelve inches in diameter although it measured only about four inches at the start of the run. Therefore, a reel with a large diameter will wind up more film during a given number of revolutions than will a smaller one. Inasmuch as the lower sprocket feeds the film to the reel at a constant speed of 90 feet per minute and yet the reel must wind up all the film fed to it, then some device must be provided that will allow the take-up reel to wind up all of the film fed to it no matter whether its diameter is small, as at the beginning of a run, or large as at the end.

The device that enables the take-up reel to properly wind up the film is a slipping clutch arrangement such as pictured in Figure 16 and consists of the following: "A" is a pulley which is belt driven from a pulley in the picture head and drives flange "B" through three pins; part "C" is a friction disc faced with leather and is attached to the shaft "F" which carries the take-up reel inside the lower magazine; "D" is a coil spring that presses the flange "B" against the leather facing of the friction plate "C" and which can be adjusted to give more or less pressure by means of the knurled nuts on the end, and "E" shows the shaft bearing fastened in the magazine bracket.

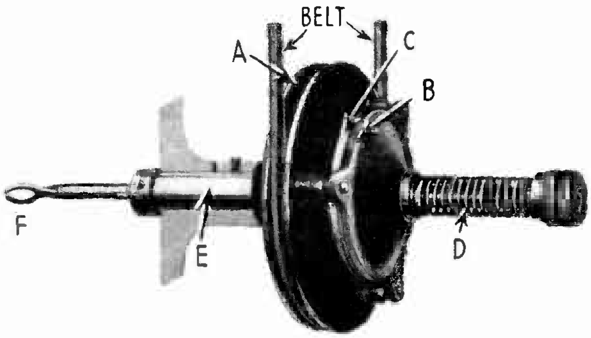


FIG. 16 -A SLIPPING CLUTCH AIDS IN WINDING UP FILM.

In operation, the path of the driving force is through the belt to the pulley, through the three pins to the flange which is free to move in and out on the pins, and thence from flange to friction plate which turns the shaft or spindle upon which the reel is mounted. The speed of the shaft without slippage is great enough to allow the reel to take-up the film when the film is at the beginning of the run and the reel of film has the smallest diameter. Since the diameter of the wound film becomes greater during the run, the slippage between the flange and the friction disc increases as the reel must run slower due to the fact that its increased diameter enables it to wind up the same 90 feet of film per minute with less revolutions. It is in this manner that the film is taken up as quickly as it is fed down by the lower feed sprocket. This sprocket is also referred to as the holdback sprocket because it holds back the film from the lower reel when it tries to wind the film faster than 90 feet per minute. The tension on spring "D" must not be too strong as it is liable to cause tearing of the film sprocket holes at the holdback sprocket.

Figure 17 shows a cut-away picture of the take-up mechanism. "A" is the pulley; "B" the shaft attached to friction disc "C"; "D" is a key which fits in a keyway in the reel hub; "E" is shown in its turned position to keep the reel from sliding off the end of the shaft; "F" are ball bearings; "G" is the tension spring; "H" is the tension adjusting nut, and "I" the locking nut.

In Figure 15 the roller "H", called the "loop-setter", is a special Powers feature and serves to keep a sufficient supply of film in the lower loop. In normal operation the lower loop encircles the loopsetter and does not touch it but should the loop grow smaller, which would occur if there were broken sprocket holes in the film and the intermittent did not move the film down as it should, the loop would then tighten around the loopsetter and lift it up as it is free to move on a lever. On the other end of the lever is a clutch arrangement that throws the lower sprocket out of gear with the driving mechanism thus stopping its motion until the loop reforms or grows to a size large enough to allow the loopsetter roller to drop back to normal.

This calls to mind the fact that both the intermittent and the lower sprocket are dependent upon the sprocket above each for a sufficient supply of film to maintain the loops upon which these parts draw, and the failure of any of the sprockets to deliver film brings about a condition that may develop into serious trouble. The most frequent causes of trouble of this kind are broken sprocket holes in the film and insufficient tension on the "pad rollers" that hold the

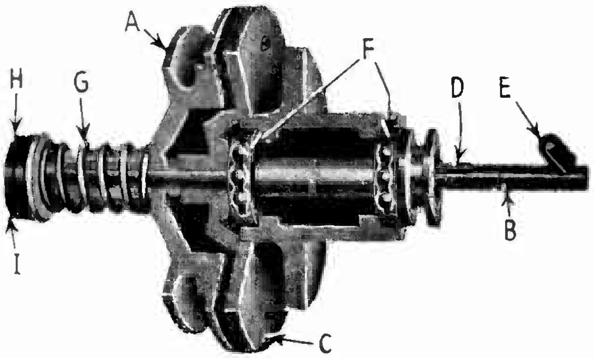


FIG. 17— CUT-AWAY VIEW OF TAKE-UP MECHANISM.

film in close engagement with the sprocket teeth. If the film "rides over" the teeth and does not pass along properly it results in shortening or losing one of the loops. If either of the loops is lost the quick motion of the intermittent, having no loop to draw upon or feed into, causes tearing out of the sprocket holes and the film is liable to become damaged. Therefore, when threading film through a projector care should be taken to see that loops of the proper size are left above and below the intermittent. This is even more important when using sound film with record reproduction as loss of synchronism may be caused by "improper threading".

## ROLLER PIN INTERMITTENT

A type of intermittent, known as the "roller pin" movement is used in the Powers projector. A picture of this intermittent is shown in Figure 18 and sketches illustrating four different stages in its operation are given in Figure 19. In both Figures 18 and 19 the part marked "W" which is known as the "pin cross" has four rollers attached to it. "X" is the intermittent sprocket which is on the other end of the shaft to which the pin cross is attached while the part called the "diamond" and marked "Y" and the "locking ring" marked "Z" both together make up the "cam".

Referring to Figure 19-A the operation of the intermittent is as follows: Both the cam and the pin cross revolve in a clockwise direction, or as the hands of a clock move. The teeth of the sprocket are shown engaged with the sprocket holes of a short strip of film, one picture or frame of which being indicated between the black lines. In Figure 19-A the four rollers of the pin cross are shown engaged with the locking ring "Z" of the cam, rollers 1 and 2 being outside of the ring and 3 and 4 inside. The ring is free to revolve between the four rollers but the pin cross cannot move because it is securely locked in place by the locking ring. Thus, while the pin cross, sprocket wheel, and film are at rest one picture or frame is projected to the screen.

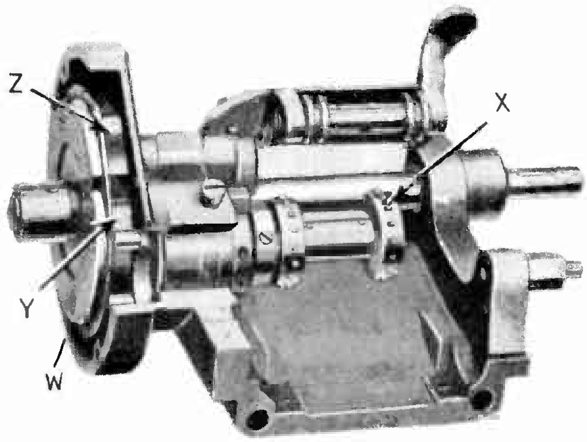


FIG. 18—"ROLLER PIN" MOVEMENT OF POWERS PROJECTOR.

In Figure 19-B the end of the locking ring "Z" is shown passing out from between the four rollers. The "diamond" of the cam then begins to engage roller 1. At this moment the forward slot "F" comes into place beneath roller 2, and the rear slot "G" above roller 4. Consequently, as the diamond pushes roller 1 forward and downward, roller 2 passes down into slot "F" and roller 4 up into slot "G". At the same time roller 3 moves over in a direction opposite to roller 1, since all four rollers are mounted on the same pin cross support. This is shown in Figure 19-C.

After the highest point of the diamond has passed roller 1, the motion is continued by the pressure of the end "H" of the locking ring against roller 4, and the bottom of the diamond against roller 2, so that the pin cross continues its motion until it has made one-quarter turn. The rollers are now in the position shown in Figure 19-D. Locking ring "Z" is now ready to slide once more between the four rollers, thus locking them and the intermittent sprocket.

Since the intermittent sprocket has sixteen teeth on its circumference, it has moved through four teeth in its one-quarter revolution. Since there are four teeth to each frame, it is evident that in one-quarter revolution the film has moved one frame.

Thus for one revolution of the cam, the film has moved one frame after the diamond has actuated the pin cross, and the locking ring now holds the pin cross, intermittent sprocket, and film stationary while the frame is projected upon the screen.

The sequence of operations described above constitute one "cycle" of the intermittent movement. In sound motion picture projection, there are twenty-four such cycles per second, so that projection is at the rate of twenty-four pictures or frames per second, which is equivalent to ninety feet of film per minute.

The particular intermittent described above has a high ratio of time when the film is stationary to that when it is moving. This is desirable in that during most of the cycle the film is stationary and therefore in a condition to be projected upon the screen, and only a very short interval of time is required to move the film for the projection of the next frame. Hence, as will be explained in the succeeding paragraph, the light need be cut off for only a very

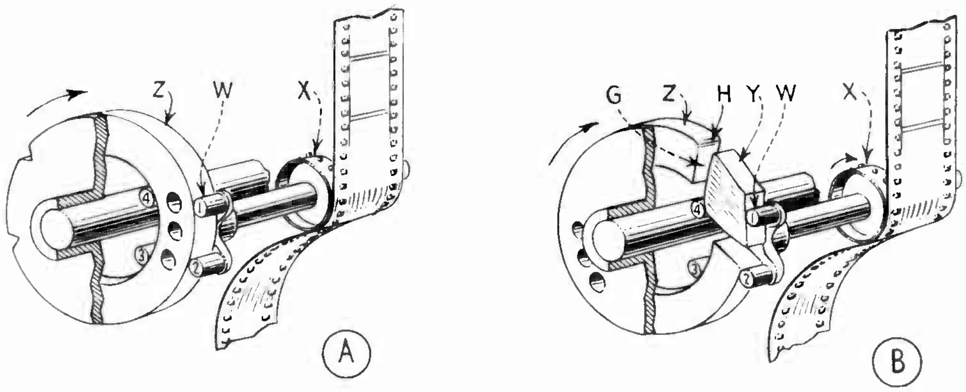


FIG. 19-A — INTERMITTENT ACTION WHEN PIN CROSS, SPROCKET WHEEL, AND FILM ARE AT REST.

FIG. 19-B — LOCKING RING "Z" PASSES OUT FROM BETWEEN THE FOUR ROLLERS.

short interval of time while the film is moving, and so less light is wasted.

An ideal intermittent would be one that moved the film one frame in an infinitesimally short space of time, so that light could be shone through the frame during the entire cycle. In practice, difficulties arise in utilizing too rapid an intermittent in that the parts of the movement and the film must be accelerated at too rapid a rate, thus causing undue wear both on the intermittent movement, intermittent sprocket teeth, and film sprocket holes.

Moreover, once the film has been set in motion by the intermittent sprocket, it tends to keep moving due to its inertia, even after the intermittent is locked in the stationary position. To offset this, the pressure of the tension shoes in the picture gate must be increased, which results in greater drag on the film, and consequently increased wear.

The intermittent just described represents about the fastest movement practicable in motion picture projection and has proven to be a thoroughly reliable movement for this purpose.

THE SHUTTER AND ITS PURPOSE

We stated previously that while the film is in motion past the aperture it is necessary to cut off the light from the screen or white lines, called "travel ghost", will be seen racing from bottom to top on the screen. The apparatus used to cut off the light is called the "revolving shutter" and in the Powers projector it is located on the front part of the picture head.

Figure 20 shows the shutter in place as it appears when looking at the front of the picture head or when looking from the screen side. This part is made of thin metal and has three vanes or opaque "wings" and three openings in between the vanes. In this illustration a portion of the lens may be seen through one of the openings.

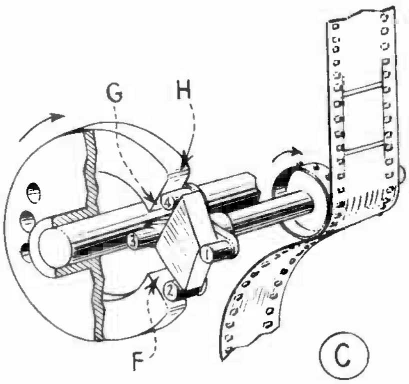


FIG. 19-C — PRESSURE EXERTED BY "H" CONTINUES THE INTERMITTENT MOTION.

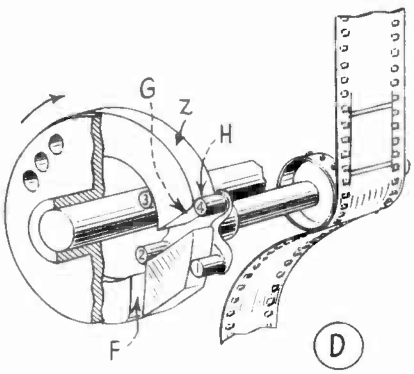


FIG. 19-D — LOCKING RING "Z" IS NOW READY TO SLIDE BETWEEN THE FOUR ROLLERS.

Figure 21 shows an edgewise view of the shutter as seen from the right-hand side or "operating side" of the projector. The same handle seen in each of these photographs is used only for making adjustments and is removed if the machine is to be operated by motor drive. Referring again to Figure 20, the revolving shutter makes one complete revolution during each movement of the intermittent which means that while one frame or picture is being moved into place and projected to the screen the three vanes and the three openings in the shutter pass successively before the lens. Accordingly, there must be three interruptions of the beam of light while each separate frame or picture is being projected. At this point you might well wonder why three vanes or blades are provided on the shutter and the beam of light is interrupted so many times inasmuch as we stated before that in order to eliminate "travel ghost" it is merely necessary to cut the light from the screen while the film is being moved by the intermittent and it is obvious that this can be accomplished by one of the three blades. Therefore, it follows that the extra two blades act to cut off light while the film is at rest in the aperture and, hence, they are not provided for the purpose of eliminating travel ghost.

To explain the use of the extra blades we must consider another natural quality of the human eye in regard to effects caused by quick flashes of light. This is commonly known as "flicker" and is the effect we would get if the light passing through the film were interrupted at too slow a rate.

We know that due to persistence of vision 16 pictures per second will blend into a continuous single moving picture but when it comes to flashes of light they must occur at a rate of from 50 to 60 per second in order to appear as steady flickerless illumination on the screen. It should now be clear why three blades are required on the shutter.

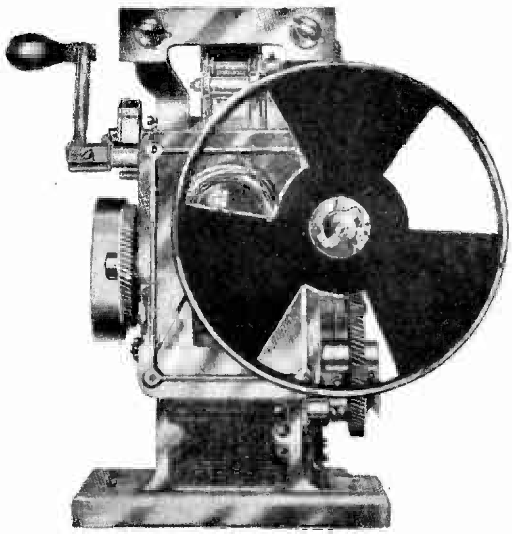

FIG. 20—FRONT VIEW OF POWERS HEAD.

The blade that cuts off the light while the film is moving past the aperture is called the "master" blade because it prevents "travel ghost", while the other two are known as "flicker blades" because their only function is to reduce flicker.

More than 50% of the light which would otherwise pass to the screen is intercepted by the blades of the revolving shutter and therefore is lost to useful work. This loss represents a considerable amount of actual money that must be spent for electric current and larger lamphouses required to produce the extra light needed to properly illuminate the screen. However, the steady, flickerless illumination received in return is worth the extra expense in view of the fact that flickering is not only annoying and tiring but in extreme cases it is harmful to the eyesight. By proper adjustment of the shutter the rotation of the blades may be timed so that the light will be entirely cut off from the screen by the master blade before the intermittent starts the film moving in the aperture and will remain cut off until the film comes to rest. This adjustment must be made before showing a film or otherwise varying degrees of travel ghost will result. The adjustment on the driving mechanism of the shutter that allows it to be accurately "timed" to correct a condition of travel ghost is made by merely turning a hand screw until the effect on the screen disappears.

PROTECTION FROM FIRE

Another feature incorporated in the picture heads of modern machines is the automatic fire shutter. One type, shown in Figure 22, is composed of the following units: An automatic fire shutter governor "A", a lever "B" attached to the governor, a curved rod "C" attached rigidly to the shutter itself, and a piece of sheet metal "D" hinged at the top so that when closed, as in the position shown, it entirely covers the picture aperture.

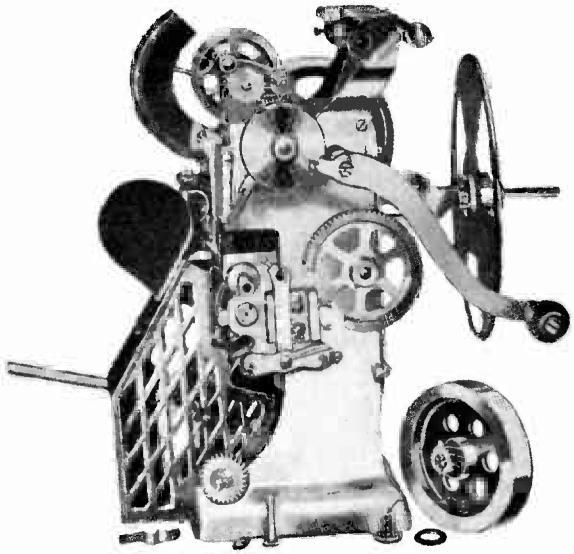

FIG. 21-OPERATING SIDE OF POWERS HEAD.

The sole purpose of the fire shutter is to prevent the film from catching fire in the event the machine stops running or even slows down to a speed that allows less than 40 feet of film to travel through per minute. A device that furnishes this protection is absolutely necessary because the heat rays as well as the light rays of the arc lamp focus to a spot on the aperture and are so intense at this location that the film will catch fire almost immediately if it stops or even slows down too much. Providing a film continues to move fast enough past the aperture no part of it remains in the heat area sufficiently long to catch fire. To prevent any possible trouble from this course the fire shutter is made so that when the machine is at rest or coming to rest the aperture is covered by flap

"D", thus, when the flap is down the film is shielded from the light and heat of the "spot". When the machine is started flap "D" remains down for a time, or until the speed of the film past the aperture is up to 40 feet per minute and after this point the governor

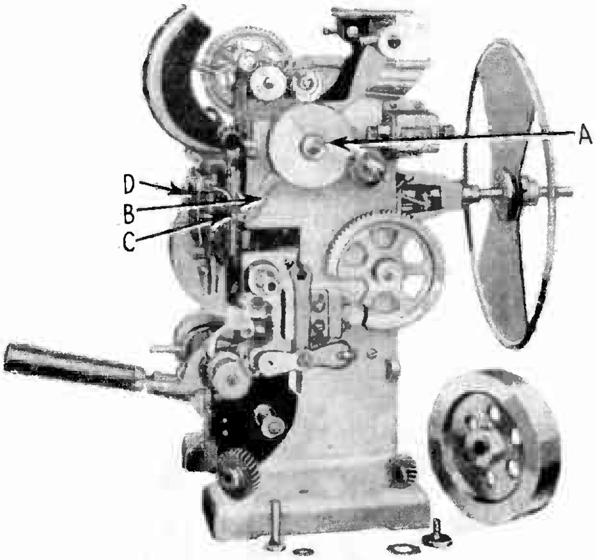


FIG. 22 AUTOMATIC FIRE SHUTTER PROTECTS FILM.

lever "B" pushes on the curved rod "C" and raises the flap. With the flap in the raised position the aperture is open to the light rays which are free to pass through the film, the lens, and the shutter openings to the screen. On the other hand if for any

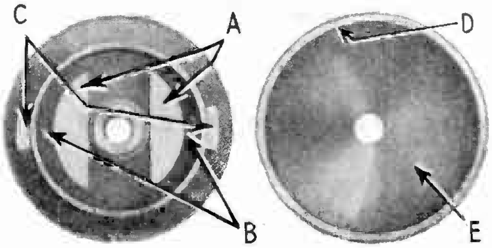


FIG. 23 GOVERNOR OF AN AUTOMATIC FIRE SHUTTER.

reason the projector slows down to less than 40 feet of film travel per minute the lever "B" moves back and causes the flap to fall down over the aperture and cut off all light and heat from the film.



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The internal construction of the governor "A" is shown in Figure 23. Its mechanical operation is as follows: Two governor weights "A" revolve with the casing in which they are contained and connect with two friction shoes "C" through two spiral springs "B". As the governor weights come up to speed they move outward against the springs and transmit pressure to the two friction shoes. When assembled, the cover "E" fits over the casing that contains the governor weights and the friction shoes "C" bear outward against the inside of the rim "D". Note that while in operation the casing and cover are closed together like a book. When the outward pressure of weights "A" (as applied through springs "B" to shoes "C") is great enough due to the projector coming up to speed, the friction of the shoes on the inner surface "D" turns cover "E" and since the latter is attached to the flap it raises the flap and the aperture is left open to admit the light rays.

## THE FRAMING DEVICE

Projectors are also equipped with a framing device. Framing is necessary to keep an entire frame or picture in place before the aperture instead of allowing parts of adjoining pictures to be shown simultaneously on the screen. The handle of a framing device is shown sticking out from the rear of the picture head in Figure 14. By raising or lowering this handle the intermittent sprocket and the film in the picture gate between the upper and lower loops may be moved up or down until the position is found where only a single picture is accurately "framed" in the aperture. This adjustment can be made while the projector is running. Although the mechanical features of various projectors may differ the principle of "framing" remains the same, that is, the film is moved to a position where one complete picture at a time is placed exactly in the aperture by the movement of the intermittent.

The remaining very important feature of motion picture projectors, the lens, is taken up under the subject of "Light and Lenses".

## EXAMINATION QUESTIONS

1. Name the three main sprocket wheels in a projector head and give use of each.

2. Why is a master blade used in a revolving shutter and when does it come into action?

3. What part of a carbon arc is the source of the most intense light?

4. Name any blades other than the master blade of a revolving shutter and explain their purposes.

5. What happens when a picture becomes "out of frame", and how is the condition remedied?

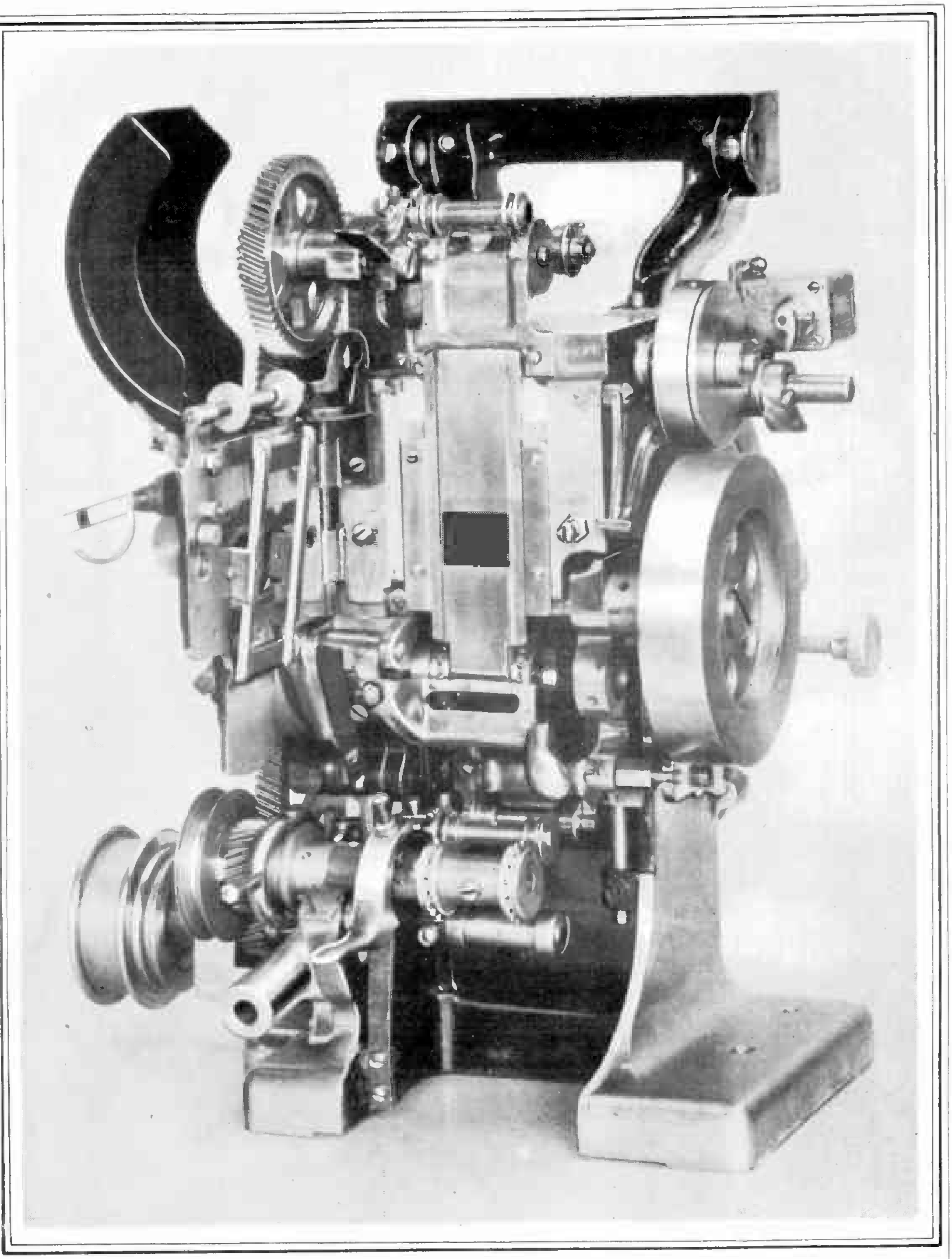
6. (a) What mechanism pulls a film into place in the aperture?
   (b) What type of mechanism is employed in the Powers projector for this purpose?

7. What mechanism comes into play if the projector slows down or stops?

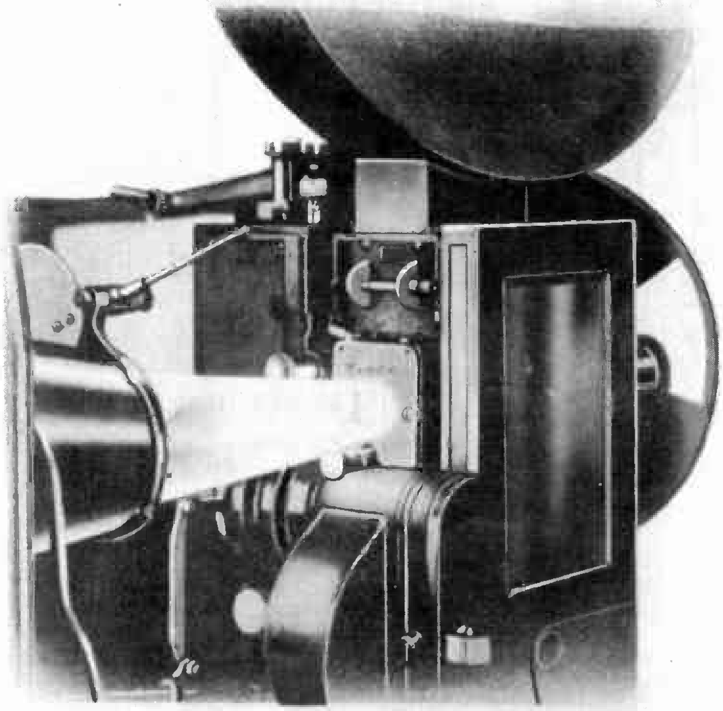
8. Why are loops of film provided above and below the intermittent movement?

9. What does the term "striking the arc" mean?

10. How many times per second is the light beam cut off when a three-bladed revolving shutter is used?



*Powers picture head showing aperture, picture gate and sprockets.*



*A light beam as it appears in its travel toward the picture head aperture.*

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