

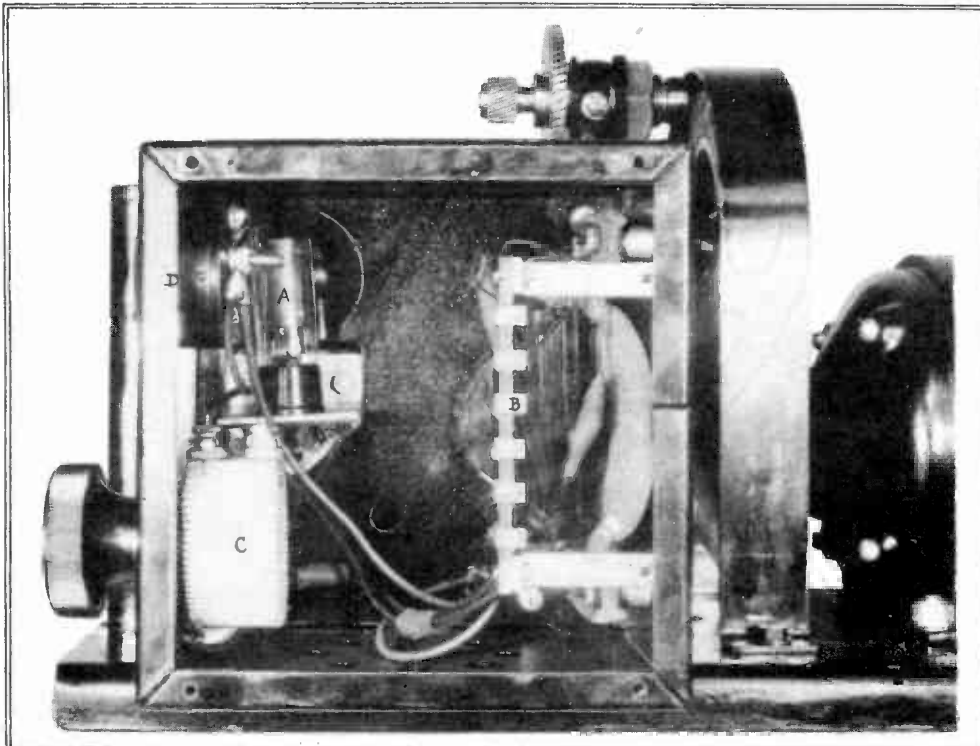
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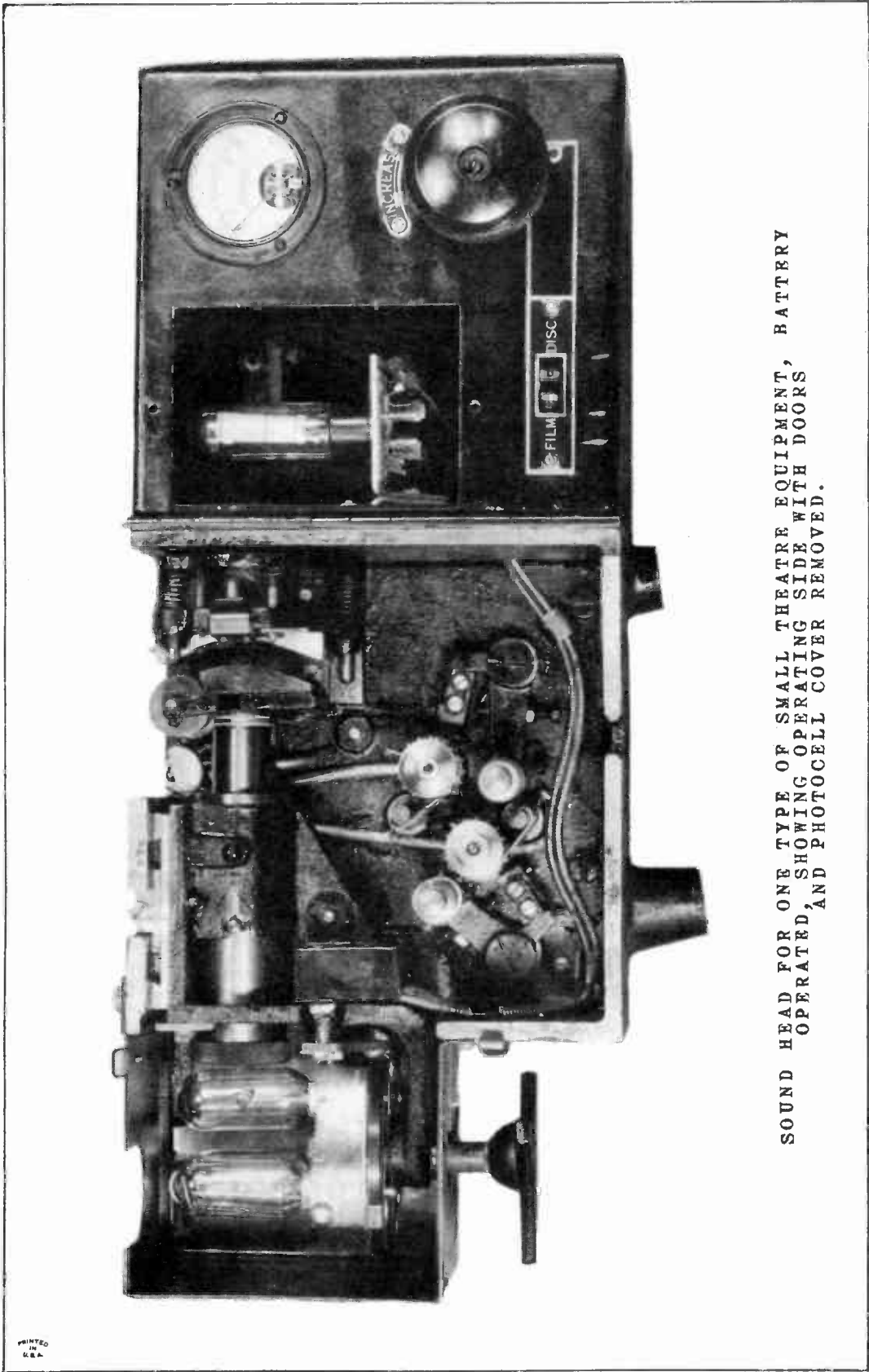


SOUND HEAD FOR SMALL THEATRE EQUIPMENT, MOTOR  
GENERATOR OPERATED, FOR POWERS PROJECTOR,  
SHOWING PHOTOCELL, PHOTOCELL TRANSFORMER,  
EXCITER LAMP RHEOSTAT, AND  
EXCITER LAMP AMMETER.

## Sound Heads Used With Standard Motion Picture Projectors

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*Dewey Classification R 580*



SOUND HEAD FOR ONE TYPE OF SMALL THEATRE EQUIPMENT, BATTERY OPERATED, SHOWING OPERATING SIDE WITH DOORS REMOVED, AND PHOTOCELL COVER REMOVED.

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## SOUND HEADS USED WITH STANDARD MOTION PICTURE PROJECTORS

### PURPOSE OF SOUND HEAD

The sound head is the unit in the sound system which changes the photographed sound wave, located on the sound track of the film, into variations of an electrical current. This varying electrical current is then amplified until it is of sufficient strength to actuate the loudspeakers to the degree required for adequate sound volume in the auditorium or theatre where it may be used.

In order to translate the photographed sound into a variable electrical current, at least three units are required in the sound head.

1. A source of light and means for shaping it into the form of a slit for scanning the sound track. This unit consists of the exciter lamp and optical system.
2. A means for pulling the film at as uniform a speed as possible past the light slit. This consists of the sound gate, constant speed sprocket, and associated driving means.
3. A means for translating into electrical current variations the light variations produced as the photographed sound more or less obliterates the light passing through the sound track. This translating unit is known as the photoelectric cell.

Each of the above units required in the sound head are described in detail in this lesson.

### LOCATION OF SOUND HEAD

Motion Picture Projection Machines and Picture Heads were, of course, in existence long before the advent of Sound Motion Pictures. These machines were costly devices. The problem of the sound apparatus designer was to construct the sound mechanism so that it could be conveniently attached to existing motion picture projectors. The most logical and convenient place for the attachment was immediately beneath the motion picture projection head. Sound Heads are therefore found always mounted in this position. The adoption of the mounting of the sound head immediately below the picture head in the first design resulted in a recording restriction which has made it a hard and fast rule that sound heads must always be mounted in this

relative position. The first sound heads were so designed that, when the film was properly threaded in them and in the picture head, there was a linear measurement of film of 14.25" or 19 frames between the picture optical system and the sound optical system. Since both picture and accompanying sound must be projected simultaneously it is obvious that the sound must be recorded on the sound track exactly 14.25" ahead of the picture to which it corresponds. Sound-on-film recordings have therefore been made in this manner from the start and will have to be made so until existing sound projectors are no longer in use. By the same token, correspondingly, sound heads will always continue to be designed and mounted so that there will be exactly the proper length of film between the two optical systems.

Figure 1 depicts a typical sound head and Figure 2 shows a sound head mounted on a standard motion picture projector.

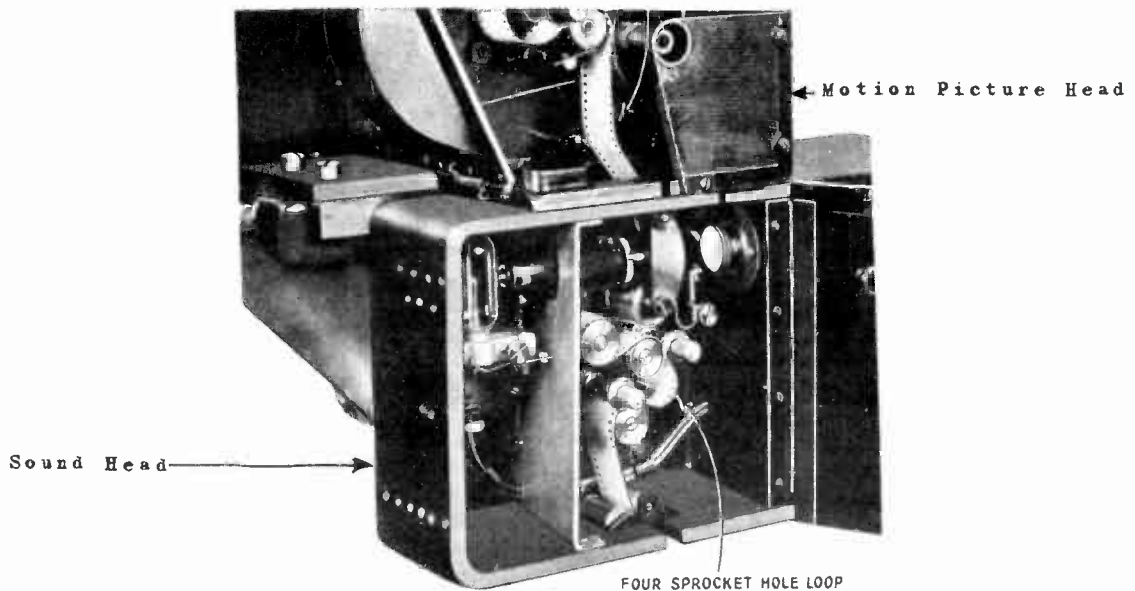


Fig. 1 - TYPICAL SOUND HEAD WITH FILM THREADED IN PLACE.

#### SOUND HEAD CONSTRUCTION.

The sound head must be of rugged construction. The relationship of the various parts and the delicacy of the adjustments require working tolerances of the order of one thousandth of an inch or less. Weaving or warping of the sound head housing cannot be tolerated and it is therefore always made of heavy pressed metal, or it consists of a unit casting, or of several castings bolted together.

#### SOUND-ON-FILM RECORDING.

It has elsewhere been noted that sound is a vibration of the air or other medium of such frequency as is capable of affecting the ear and producing the sensation of sound in the brain. The pitch of the sound depends upon the number of vibrations made per second; a note

of high pitch corresponds to many vibrations per second and a note of low pitch, to few vibrations per second.

Thus, a 9000 cycle note is one in which 9000 to and fro vibrations are made by the air particles in one second. The light beam of the oscillographic recorder must therefore make 9000 such oscillations per second across the sound track of the recording film (variable area type recording). The speed of the film is 90 feet per minute, or 18 inches per second. Therefore, in 18 inches of film, 9000 to and fro light streaks, hence black lines on the film, must be accomodated. This means that each streak, or "peak" as it is called, and the "valley" between it and the next "peak", must both occupy a space of  $18" \div 9000 = .002"$ . Hence, the "peak will be .001" wide, and the "valley" will be the remaining .001" in idth.

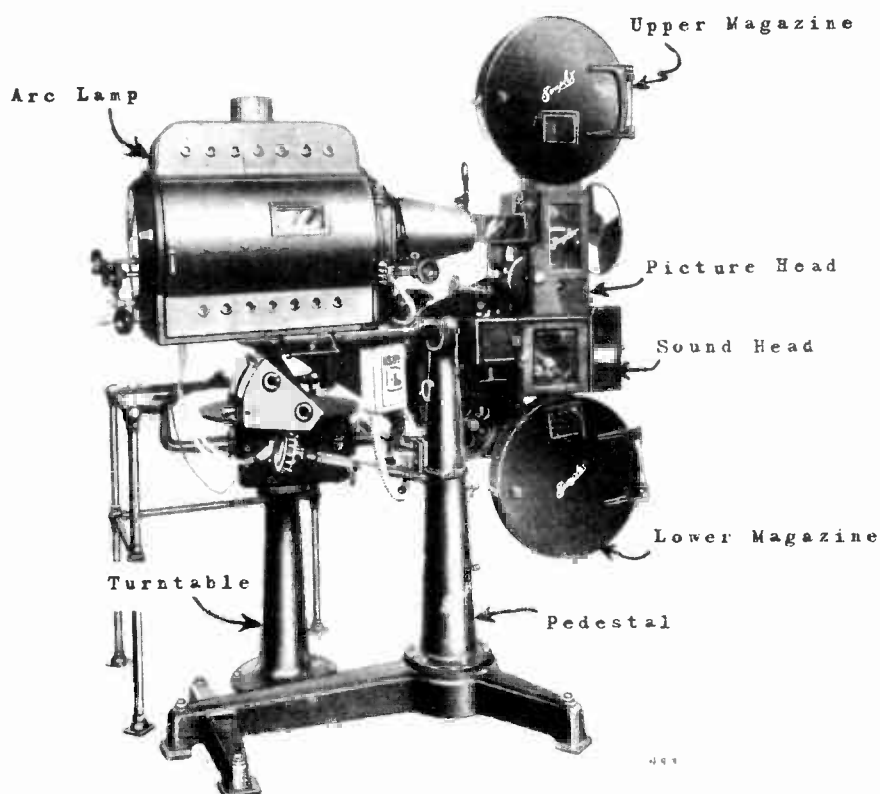


Fig. 2 - SOUND HEAD MOUNTED ON A STANDARD MOTION PICTURE PROJECTOR.

A 100 cycle note, however, can be  $18" \div 100 = .18"$  wide, that is, the "peak" and the "valley" will each be .09" in width, or ninety times as wide as that of the 9000 cycle note. This brings out the interesting fact that the higher the frequency, the narrower must be the peaks and valleys representing the photographic recording of the sound on the film, since, for high frequencies, more peaks and valleys must be recorded in the same 18 inches of film per second.

If we wish to record or to reproduce these higher frequencies, it is essential that the light slit scanning these peaks and valleys be

comparable to them in width. It can be shown mathematically that a light slit .001" in width will just fail to be affected by an 18000 cycle note. This is about the limit of audibility, but the obliterating effect of even lower frequencies and hence wider peaks and valleys is reduced from 100 per cent modulation or obliteration, i.e., a 9000 cycle note, or even a 5000 cycle note of the same amplitude as a 100 cycle note, will not modulate the light slit as completely as the 100 cycle note.

There will be, consequently, a falling off in response at the higher frequencies, even if the amplifier and loudspeakers were perfect, due to this slit loss in the sound head, and, as explained above, this loss is due to the fact that the slit is finite, instead of infinitesimal in width.

From the foregoing, we perceive the need for a very fine slit to scan the sound track, in order that the finest lines of the recording, (representing the highest frequencies) may produce the maximum variation in the light impinging upon the photocell, and thus be reproduced as strongly as the lower frequencies. In practice a light slit .001" wide (or rather high, as this dimension is termed by recording engineers) by .070" wide, is employed. Such a slit will reproduce even a 6000 or 7000 cycle note without undue loss (attenuation), and consequently is capable of giving good reproduction of sound.

#### EXCITER LAMP AND OPTICAL SYSTEM.

The exciter lamp produces the light, and the optical system shapes it into the form of a slit upon the sound track of the film. Although a mask could be placed against the film, and the slit placed directly in this mask, so as to allow only a narrow slit of light to pass through the sound track of the film from the exciter lamp, such a means is not usually employed in practice. The reason is that any dirt or oil on the film would quickly deposit and block up the fine slit in the mask, and spoil, if not actually stop, the sound. Moreover, as the film passed over the mask, it would wear it in time, and change the dimensions of the slit.

As a consequence, the mask with the slit in it is not located at the film, but is tucked away in a barrel or metal cylinder where it can be shielded from all dirt and oil. Between this physical slit and the exciter lamp is placed a condenser lens to gather the light rays from the exciter lamp and concentrate them on the slit. Between the slit and the film, i.e., at the other end of the barrel, is placed an objective lens to focus the illuminated slit upon the sound track of the film.

We have thus formed at this latter point an image, or optical slit, which scans the sound track, and as this slit is nothing but focused light, it cannot wear out, nor can any dirt cling to it. Furthermore, by employing well-known principles of optics, we can make this optical slit a reduced image of the physical slit by a suitable choice of objective lens and distances between it and the film on the one hand, and the physical slit on the other hand. Thus the physical slit can be made larger, which allows more light to be passed through it for a given mechanical arrangement, and also enables the slit to be manufactured more accurately, since a given tolerance constitutes a smaller percentage of its dimensions.

the optical arrangement is shown in Fig. 3. It will be evident from this figure that this system represents in miniature the projection of a picture by the picture head. Thus, the exciter lamp corresponds to the arc lamp, the condenser lens gathers the light and concentrates it upon the slit, which corresponds to a picture frame in the film. Then the objective lens, corresponding to the picture lens, picks up the light from the illuminated slit, and forms an image of it upon the sound track of the film, which corresponds to the picture screen. The main difference is that a magnified image of the picture on the film is produced on the screen, whereas here a reduced image of the slit is formed on the sound track of the film.

As can further be seen from Fig. 3, the light, after impinging upon the sound track in the form of a slit, passes through to the photocell. In most systems the latter has but a small window through which the light must pass, and as the light beam diverges after focusing on the film, it must be gathered together again by the photocell. Photocells having a large window do not require this second condenser lens.

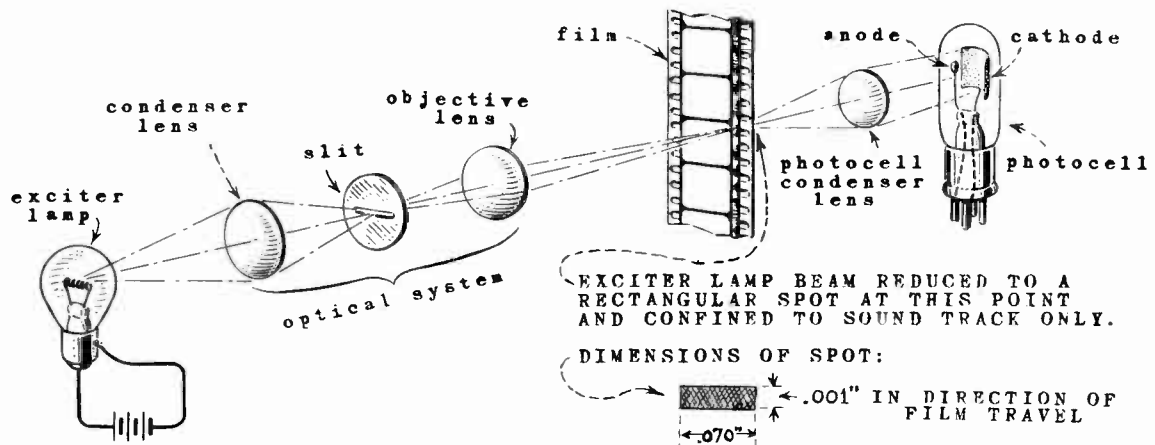


Fig. 3 - OPTICAL ARRANGEMENT AND LIGHT SYSTEM FOR SOUND-ON-FILM REPRODUCTION.

#### SOUND GATE AND FILM DRIVE.

It is evident from Fig. 3 that the slightest motion of the film toward or away from the optical system will throw the slit image out of focus on the sound track of the film, and thus result in an enlarged, blurred slit image. This will, as explained above, cause marked attenuation of the higher frequencies in the recording and consequently impaired reproduction. In addition, the slightest weaving of the film sidewise will cause the slit image to scan either the sprocket holes or the picture frames of the film. These will modulate the light, and cause unwanted sound in the loudspeakers, since the photocell is incapable of discriminating between sound recording modulation of the light and any other cause of modulation.

Hence the film must be held in place very accurately where it passes the light slit, and for this purpose a sound gate is provided. One

form of sound gate is shown in the photograph of the sound head on the inside back cover page. Here a curved sound shoe, or guide plate, is used and in operation the film has a natural tendency to wrap itself around this member and hug it tightly as it passes over it because of its curvature. The action may be compared to that of a polishing rag run over a shoe when polishing it. The film is also aided in keeping to this surface by the tension pad, on which are mounted two tension shoes, like sled runners. The bottom of the one nearest the projectionist can be seen in this photograph of the sound head.

These tension shoes press against the edges of the film, where the sprocket holes are located and hold it against the guide plate. Any wear or scratching of the film occurs at the edges, and not on the sound track or picture, so that these are not harmed by this pressure.

Above the gate are two guide rollers, the forward one of which can be seen just underneath the picture head. These guide rollers function as their name suggests. They guide the film into the sound gate at exactly the right position for the slit image to fall on the sound track, and nowhere else. The forward guide roller cannot move laterally whereas the back guide roller can move against the action of a small spring, which keeps it pressed against the other edge of the film. In this way any irregularities in the width of the film are taken up by the rear guide roller, while the forward one remains fixed laterally, and prevents any shifting of the forward edge of the film, since it is next to this edge that the sound track is placed.

A loop is left in the film above the sound gate, as shown, in order that the sprocket above the loop impart no irregularities to the motion of the film passing through the sound gate. Below the latter is placed the constant speed sprocket to pull the film through the gate. The photograph shows that two smooth rollers are interposed between the gate and the sprocket, their action being explained below.

In passing, it is to be noted that the film touches the guide plate only at the edges, where its sprocket holes are located. The central portion of the plate is depressed below the edges, and does not touch the film. A hole is cut out in this central portion to let the light through onto the film. While this hole need only be slightly larger than the fine slit of light, in practice it has been found advisable to make this much larger, in order that it will not be blocked up by dirt from the film, and thus cut off the light. This may appear like a small detail yet the practical success of the sound head depends upon an unobstructed light slit.

#### CONSTANT SPEED DRIVE.

Film is very light in weight, and can easily be accelerated or slowed up. Hence, any irregularities in the driving gear are readily imparted to the film, and it is essential that the drive gear be made to turn at an absolutely constant speed. This requirement can be appreciated from the following considerations. In order that the reproduced sound be a faithful copy of the original, it is necessary that the film in the projector move past the light slit in exactly the same way as the recording film negative moved past its light slit in the recording mechanism. The simplest way in which this similarity in motion can be obtained is to move both films at an absolutely constant speed. If one or the other does not, distortion will be the result.



In recording great care is exercised to bring about this condition. In reproducing sound, similar care must be exercised. A brief review of a few of the methods employed for insuring constancy of speed are given in this lesson, however, the mechanical features of these methods are described in detail.

Although the sound is recorded at a film speed of ninety feet per minute, it is not absolutely essential that the film be run through the projector at this particular speed. Thus, film speeds between eighty-eight and ninety-three feet per second are satisfactory, as the difference in pitch is negligible from an aesthetic viewpoint. Indeed, you may have noticed that various pianos are not all tuned to the same pitch, although the various notes of any given piano must be in tune with one another.

Because of these conditions it is perfectly feasible to run the projector by means of an induction motor which, as you know, runs at slightly below synchronous speed. Moreover, slow variations in speed, if the variations occur within a narrow range, will not be noted by the ear, so that it is permissible to have small variations in line voltage, which will vary the speed of the motor to a slight extent.

The prime requisite is to have the film pass the light slit at an absolutely uniform speed — at least, there must be no abrupt change in speed. If the film moves at the rate of 90 feet per minute, any point of it traverses 18 inches in one second, or 0.18 inch, for instance, in one hundredth of a second. It is possible, however, for the film to traverse 0.16 inch in the first hundredth of a second, and 0.20 inch in the second hundredth of a second. The average speed will be 0.18" per hundredth of a second, or ninety feet per minute, yet it is obvious that the film is not moving at a uniform rate of speed. If these variations follow each other very rapidly, we get a modulation of each cycle of sound recorded, and this results in the production of harmonics with consequent harshness of tone. If the variations are of a slower periodicity, the tone sounds "wavery", and this is particularly noticeable in piano music, where each tone dies away after the string is struck by the hammer. These fast "wows", as they are called, cause the tone to die away with a vibrate effect, and so piano music is used as a test for this effect.

From the above it is evident that if the constant speed sprocket below the gate be driven directly through a train of gears by the motor, the gear vibration will be transmitted to the film and result in imperfect reproduction of sound. To prevent this, practically all sound heads have some sort of a flywheel through which the drive is transmitted to the film. The flywheel thus acts as a heavy mass which is coupled to that portion of the film passing through the sound gate, and so loads up the light film to a degree which gives it sufficient inertia to pass smoothly through the gate.

One common form is to mount the flywheel on the same shaft as the constant speed sprocket. Hence, the sprocket and the film meshing with it are constrained to move at a uniform speed. The flywheel is not driven directly through a train of gears by the motor. Instead, it is driven from the driving pinion through a series of springs, which take up the vibrations and thus do not transmit them to any extent to the flywheel. The latter, in turn, has too much inertia to respond to any degree to such vibrations as may come through the driving springs.

However, you will note that the flywheel and springs correspond very much to the balance wheel and hair-spring of a watch and hence, are liable to vibrate in exactly the same way as the balance wheel does when given an impulse. This impulse may be due to various causes, such as a film patch passing over the constant speed sprocket. Such an oscillation would result in "wows" in the reproduction (variations in pitch) and could not be tolerated. Hence some frictional damping means must be employed to prevent such oscillation.

One type of sound head employs a felt washer, lubricated with Alemite grease, to press against the face of the flywheel. The viscosity of the grease acts as a smooth frictional damping means. Another type of sound head employs a dashpot arrangement for this purpose. The dashpot is in the form of a pair of thin brass bellows, from which air can escape, or into which air can enter, through a pinhole in each. As the flywheel oscillates with respect to its driving member, these bellows are distended and contracted, and as they do so, the air is drawn in or forced out, respectively. It is the frictional force of the air passing through the pinhole that serves as the damping means.

A third system employs a smooth roller known as an impedance roller, over which the film passes, and which is caused to revolve due to the frictional contact of the film with its surface. The film thus acts as a drive belt for it. The shaft on which the roller is mounted carries a flywheel on its other end. The latter prevents the roller, and hence the film passing over it, from varying in speed, so that here we have another example of the light film being loaded up with a heavy weight to give it more inertia. In some other models, the constant speed sprocket below the impedance roller is itself driven from the motor through three "V" belts passing around a huge flywheel mounted on the same shaft as the constant speed sprocket. This further insures constancy of speed.

The sprocket following the constant speed sprocket is known as the take-up or hold-back sprocket. Since the pull of the lower take-up reel varies with the amount of film wound on it, and this pull may be very uneven if the reel is bent, it is apparent that a take-up sprocket takes up this pull and prevents it from being transmitted to the constant speed sprocket. This is further aided in most sound head designs by leaving a small loop between the two sprockets.

#### PHOTOCELL AND PHOTOCELL CIRCUITS.

The photocell is located behind the sound gate, and receives the fluctuating light that passes through the sound track of the film. The photocell has the remarkable property of emitting electrons from its cathode in direct proportion to the amount of light impinging upon the cathode. An ordinary "B" battery then draws these over to a small anode or plate and thence around through the coupling impedance or load and the rest of the circuit.

We thus have an electric current flowing which is directly proportional to the amount of incident light. If the light varies, so will the current, therefore the latter becomes an electrical replica of the fluctuating light and also of the original sound vibrations. The fluctuating or variable current flows through the load impedance and sets up a fluctuating voltage drop in it. This voltage drop can then

be applied between the grid and cathode of the first tube in the amplifier, and amplified through the latter, until we obtain from the last stage, or power tubes, sufficient fluctuating voltage and current to energize the loudspeakers and obtain adequate sound.

The photocell has a high internal impedance — in the neighborhood of a megohm or more — depending upon the type of cell used. For proper energy transfer, the load impedance in its circuit must be comparable to it in value. However, if the load impedance is separated from the photocell by any considerable distance, we shall find that the capacity of the connecting leads begins to have a marked and injurious effect. The connecting leads consist of an insulated copper wire and a ground return — usually also of copper wire. The two leads form the two plates of a condenser, of which the insulation is the dielectric. While the capacity of this condenser is small, its reactance at high frequencies becomes comparable to that of the load impedance, and thus it acts as a shunt to the latter. As a result, only a small part of the high frequency currents pass through the load impedance, causing the higher frequencies to be attenuated.

Moreover, a high impedance circuit of low signal level is very sensitive to stray voltages existing in its locality, so that all sorts of "static" from the arc lamps, etc., will be picked up by the circuit. To obviate this, either of two methods is used:

1. Locate the load impedance and a portion of the amplifier close to the photocell, i.e. in the sound head, or...
2. Use a step-down transformer located at the photocell to change from a high impedance circuit to one of low impedance. The latter circuit can then be run for a considerable distance to a step-up transformer located in the amplifier rack, and there the signals stepped-up to their original voltage by means of the latter transformer for application to the grid of the vacuum tube in the first stage of the amplifier.

In the first method, as used by the Western Electric Company and a number of other manufacturers, the load impedance is a resistor of about 1/2 megohm resistance. Since a resistance has the same impedance at all frequencies, it can be less in value than that of the photocell, with the result that although the gain is reduced, the response at the higher frequencies is not appreciably attenuated due to the inter-electrode capacity of the first amplifier tube. This resistor is coupled to the grid of the first tube through a coupling condenser and grid leak; in short, the photocell is resistance coupled to the first tube. The latter is in turn resistance coupled to the second tube, which is connected to a transformer. The latter is of the step-down type, so that the secondary can be connected to a low impedance line running to the fader and thence to the main amplifier located elsewhere in the booth. The pick-up (for disc reproduction) is connected into this low impedance line running to the fader, for the signal output of the pick-up is much greater than that of the photocell, and does not require the two stages of amplification in the sound head.

It will be noted in this arrangement that instead of using a transformer to step-down from the photocell to a low impedance line, two

stages of amplification are first employed in the sound head itself, and then the step-down is made to the low impedance line. The advantages are two-fold:

1. The signal is built up so that any noise ("static") picked up is less in proportion to the signal.
2. The vacuum tubes have a much lower impedance than the photocell, so that it is easier to match the transformer primary impedance to that of the plate resistance of the second vacuum tube than it would be to the photocell itself.

The above two-stage amplifier is usually located in the sound head so that the lead between it and the photocell may be as short as possible. Such an amplifier, followed by many more stages in the main amplifier rack, is bound to be microphonic, so that it must be mechanically insulated from the vibrations occurring in the sound head. This is accomplished by mounting the entire amplifier chassis on long coil springs and rubber pads, and care must be exercised to see that the chassis never directly comes into contact with the sound head housing.

The method of coupling a transformer directly to the photocell is used by RCA Photophone in its equipment. This transformer is large in size and made of very high grade material, with its primary wound with thousands of turns of fine wire in order that its impedance be sufficiently high for the photocell. Its step down ratio is 12 to 1, and the secondary impedance is 3500 ohms (except for the PG-30 and PG-28 equipments, for which it is 500 ohms and the step-down ratio correspondingly greater). In either case the impedance is sufficiently low to allow this circuit to be run for a considerable distance to the amplifier rack, which houses all the stages of amplification. Thus, the use of a pre-amplifier in the sound head is obviated, and the only thing present at that point is the above-mentioned photocell transformer. The latter must be mounted on rubber in the sound head, as otherwise the mechanical vibrations would be picked up by its laminated core and thus modulate its electrical output and cause these noises to be reproduced in the loudspeakers. It is also to be noted that it must be located very close to the photocell so that, as in the case of Method 1, the lead joining it to the photocell be as short as possible.

#### MISCELLANEOUS.

Besides the switching arrangements between the sound-on-film and sound-on-disc circuits and apparatus, the sound head usually carries an ammeter to indicate the current through its exciter lamp, and an exciter lamp rheostat to control this current. Finally, it must be remembered that in all the systems employed, satisfactory results may be obtained with them if properly adjusted and maintained. The variations mentioned above and in the detailed discussion to follow are dictated mainly by design and economic considerations peculiar to each manufacturing company, but as far as results are concerned, excellent sound may be obtained from any of the systems to be described. We shall now make a specific study of sound heads of different manufacture.

#### SOUND HEAD - WESTERN ELECTRIC COMPANY.

In Figure 4 is shown a Western Electric sound head. At the left we see the exciter lamp bracket, "B", and exciter lamp, "E".

It is to be noted that by turning knurled adjusting screws 1 and 3, the lamp can be moved in the directions shown by the arrows, while turning adjusting screw 2 moves it away from or toward the operator. The reason for these adjustments is that a small exciter lamp filament is used, and fairly accurate alignment of the filament with the axis of the optical system is required in order that the slit be properly illuminated. Moreover, should the filament be too far away from or too close to the slit, the condenser lens will form an image of the filament too close or too far away from the condenser lens, respectively, and thus not in the plane of the optical system. As a result, loss of illumination will occur, as well as distortion, if the slit is not uniformly illuminated over its entire height.

To the right of the exciter lamp is the optical system lens tube or barrel, "L". Window "W" enables the projectionist to check the location of the image of the exciter lamp filament with respect to the

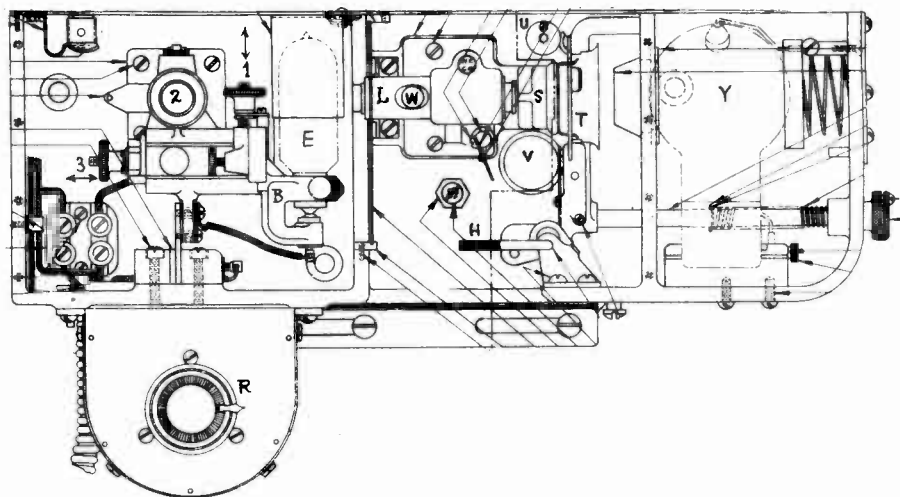


Fig. 4 - SHOWING ARRANGEMENT OF PARTS IN A SOUND HEAD.  
COURTESY OF WESTERN ELECTRIC CO.

slit. At the right-hand end of the optical barrel is the objective lens for focussing an image of the slit upon the sound track of the film as it passes through the sound gate. The optical system is adjusted and sealed at the factory, and no further adjustments are to be made in the field.

The sound gate is shown at "S". This has a straight guide plate, and above it are mounted the guide rollers "U" for the lateral alignment of the film as it passes into the sound gate. The film is held against guide plate "S" by means of tension pad "T". By moving lever "H" up and to the right, "T" can be pushed back toward the photocell house, i.e., the gate is opened for threading the film through it.

Tension pad "T" can then be removed for cleaning purposes, as emulsion will pile up in the gate after several reels are run through it.

At "V" is shown the constant speed sprocket which pulls the film through the gate. The film thereafter passes over a guide roller (not

shown) down a film chute, and over the take-up sprocket, which is located in the lower magazine (not shown). From thence it passes onto the lower take-up reel.

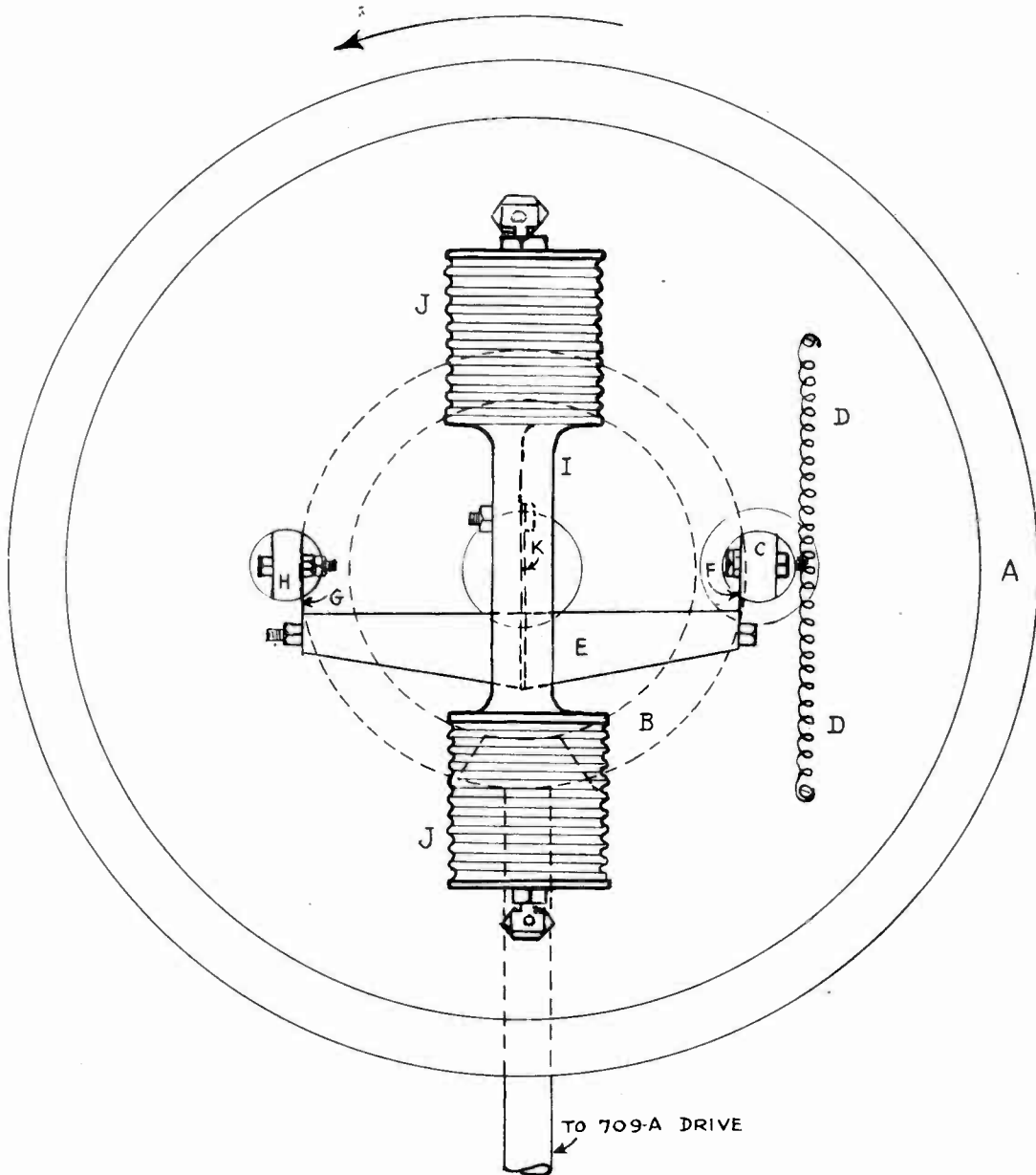


Fig. 5 - MECHANICAL FILTER FOR THE CONSTANT SPEED SPROCKET.

The photocell, "Y", is located behind the sound gate in order to intercept the light passing through the sound gate. It feeds into a resistance-coupled two-stage amplifier located in a compartment below it (not shown).

Finally—"R" is the exciter lamp rheostat to regulate the current passing through it. This current should not exceed 3.9 amperes.

An interesting feature is the method of driving the sound head. Considerable design difficulty has been experienced by the various manufacturers in devising a drive for the sound head attachment, since it has had to be "tacked on" to the picture head, after all, as an afterthought upon the advent of sound. In the case of the Western Electric equipment employing the Universal base, the motor shaft is in the same direction as the length of the base, i.e., perpendicular to the screen. At the rear end it drives the disc turntable through a worm gear. At the front end it drives, at right angles to itself, two vertical shafts. These have universal joints so that one may be aligned to drive the picture head, and the other the sound head. The drive for the latter employs the mechanical filter for the constant speed sprocket as shown in Figure 5. Here, a flywheel "A" is mounted on the same shaft as the constant speed sprocket. It is driven by bevel gear B (shown in dotted lines) through pin "C" and coil springs "DD", whose outer ends are fastened to the flywheel. The hole in the flywheel through which pin "C" projects acts as a stop so that "C" cannot stretch the springs "DD" beyond their elastic limit. This is necessary when starting, as the force required to overcome the great inertia of the flywheel at that time would be too great for the springs to transmit. The pin therefore stretches them until it bears up against the rim of the hole and thereupon accelerates the flywheel by direct contact with it.

Pin "C" also drives a cross bar, "E", through a flat spring "F", as shown, and causes "E" to revolve along with the flywheel. The other end of "E" is fastened to a pin "H" integral with the flywheel through the medium of a flat spring "G", similar to "F". Bar "E" in turn drives a bronze member "I" through the medium of another, longer flat spring "K" (shown in dotted lines). Fastened to the ends of "I" are two thin brass bellows, "J J", whose outer ends are fastened at diametrically opposite points to the flywheel "A".

These bellows have pinholes at their ends through which air can enter or escape, depending upon whether they are expanded or compressed, respectively. They thus act as dampers to the relative motion of the flywheel "A" with respect to driving gear "B". ("B" is driven in turn by means of a bevel gear and vertical shaft from the lower 709A drive.)

To see the action of these bellows, suppose the flywheel moves relative to the pinion "B", in a counter-clockwise direction, as shown by the arrow. Pin "H" will move downward with respect to pin "C", thus tilting the left end of bar "E" downward with respect to its right end. The top bellows will thereupon be expanded, and the bottom one contracted. Thus air will rush into the former, and out of the latter, and the friction set up as the air rushes through the fine pinholes will serve as a damper to this relative motion.

In a similar manner, should the flywheel move in a clockwise direction relative to drive gear "B", the top bellows will be contracted, and the bottom one expanded, and damping again introduced into this system. Thus oscillations of the flywheel with respect to the drive gear "B" are damped out.

The entire mechanism is housed in a recess in the flywheel, and is

shielded from dust and dirt and tampering by a cover plate which bolts on the face of the flywheel.

PS-8 SOUND HEAD - RCA PHOTOPHONE.

In Figure 11 is shown one type of sound head manufactured by RCA Photophone, Inc., and known as the PS-8 sound head. To the left are shown three exciter lamps in a turret holder "A." Any one of the three can be rotated into position in front of the optical barrel, "B," by means of the handle below. When this is done, contacts are made to the two terminals of the lamp, thereby sending current through it and lighting it. The current is read on meter "C," and regulated by rheostat "D." The knurled ring at the left of the barrel clamps a pair of condenser lens into place at that end. These focus the light upon a slit in the barrel. The slit is formed in the capped end of a short cylinder within the barrel. There is a slot "E," in the side of the barrel through which a small screw "F" passes, and this screw screws into the side of the cylinder. When the screw is tightened, the head bears upon the wall of the optical barrel, and thus clamps the slit cylinder within the barrel. The slot in the latter permits the screw to be raised or lowered, thus rotating the cylinder (and its slit) within. The latter may thus be adjusted so that its image is perpendicular to the sides of the sound track, a very important requirement for clear, undistorted sound.

Above the optical barrel is shown an arrangement, "G," similar to that of a lathe slide rest. By turning bolt head "H" the whole optical system may be moved forward or backward for the purpose of focusing the slit image upon the film. By turning screw head "I," the optical system may be moved laterally to center the slit image upon the sound track.

The curved sound gate—a feature of Photophone sound heads—is shown at "J," and the guide rollers above the gate at "K." The tension shoe holder, "L," slides along the rods as shown for the purpose of pressing the film against "J" by means of the tension shoes "M." The latter are made of a thin piece of spring steel. The tension shoe holder, "L," can be removed for cleaning. Behind the gate, in the right-hand compartment, is located the photocell, which has a caesium cathode, and is gas-filled to increase its sensitiveness. Behind the photocell is the photocell transformer. This can be seen more readily in the photograph on the front cover page. Here "A" is the photocell, "B" the photocell transformer mounted on sponge rubber, and "C" is the exciter lamp rheostat, while "D" is the exciter lamp ammeter. The spring steel for the tension shoes is shaped like an inverted U.

While the head shown in this photograph is for use with a Powers' projector, the above-mentioned parts are identical with similar parts used in the sound head shown in Figure 11. The photocell transformer, as you will remember from the earlier part of this lesson, is for the purpose of coupling the photocell to the low impedance line running to the amplifier located elsewhere in the booth.

Referring once again to Figure 11, we have the constant speed sprocket "M" with its associated pad roller "N" and stripper "O," while "P" is the take-up sprocket, "Q" its pad roller, and "R" its stripper. The lower magazine is attached to the projections "S" of the sound



head, while the picture head (Simplex) is fastened to its top by means of two bolts.

The entire mechanism is driven by a chain meshing with a small motor sprocket and large sprocket wheel mounted on the main drive shaft of the assembly. This main drive shaft replaces the original drive shaft of the Simplex projector, and has two pinions on it, side by side. One drives the Simplex head, as originally, and the other drives the sound head through a gear train.

The constant speed sprocket is driven from one of the pinions of the above gear train through a pair of spiral springs. One end of each spring fastens to a flat in the hub of the pinion; the other end, to a pin on a flywheel, which in turn is pinned to the constant speed sprocket shaft. Thus the pinion drives the sprocket through the spiral springs and flywheel. In Figure 6 we see such an arrangement adopted for a turntable drive. The principles employed, and the design of the mechanism, however, are exactly the same as for the

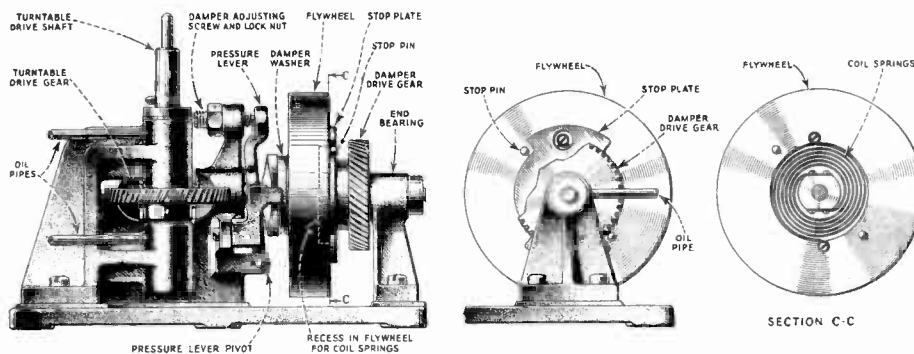


Fig. 6 - SYNCHRONOUS TURNTABLE VISCOUS DAMPING DEVICE.

sound head, so it is advisable to remember this point. It will be noted that the coil or spiral springs fit into a recess in the flywheel.

The application of this viscous damping drive to a sound head is shown in Figure 7. To increase the damping, lock nut "A" is first loosened, and its screw turned until the felt washer is pressed against the flywheel with the proper amount of force. To feed more grease into the felt washer and hence between it and the face of the flywheel, screw the top of the grease cup into its body, thus forcing the grease out of it through its feed tube into the washer.

In this figure you will also note the drive gear, which is driven from a pinion on the main drive shaft directly above it. The main drive shaft rotates in bearings in the picture head. The sound head drive gear, as you will note, has a pulley on it. This is for the purpose of driving the lower take-up reel by means of a round leather belt. Previously this reel was belt-driven from a pulley in the picture head, but after the sound head was attached it was necessary to substitute for the gear carrying the above pulley in the picture head, a gear without this pulley, as the flange on the latter

interferes with the sound head drive pinion mounted on the main drive shaft. Consequently the take-up is now driven by the pulley on the sound head drive gear, which pulley is closer to the lower take-up pulley than the flanged gear in the picture head (previously mentioned) and thus permits a shorter and more direct drive.

PS-1 SOUND HEAD - RCA PHOTOPHONE.

This is an earlier type head manufactured by RCA Photophone, Inc., and is illustrated in Figure 8. It is practically the same as the PS-8 head described above. The main points of difference follow: (1) The slide rest arrangement for moving the optical system is not employed. Instead, the optical holder is bolted by means of three bolts to the underside of the top of the sound head. Two of these bolts can be seen in the photograph. (2) The optical barrel has a vertical illuminator interposed between the slit and the objective lens. This illuminator consists of a piece of clear optical glass interposed in the light beam coming from the slit. This piece of glass

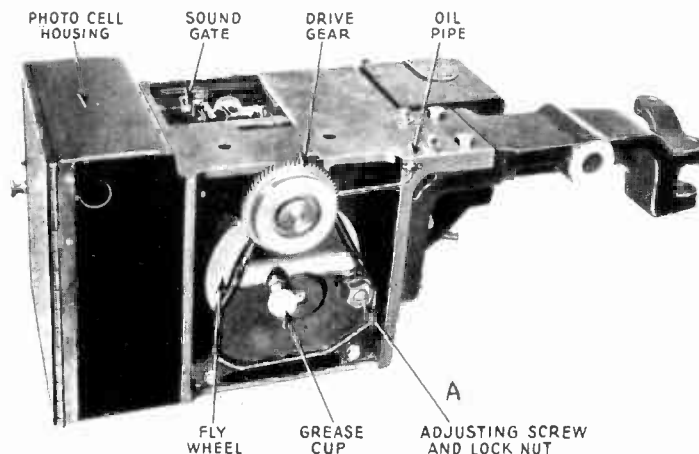


Fig. 7. - DRIVE SIDE OF TYPE PS-1 SOUND HEAD.  
(PHOTOPHONE TYPES PS-5, 6 AND 8 ARE SIMILAR.)

can be rotated by the knob to which the arrow points in Figure 8, so that it is at an angle to the light beam and thus reflects a small portion of the light coming both from the slit image and from that part of the sound track (illuminated by a flash light from the photocell housing) up through a hole at the top of the illuminator block. A periscope (Gem eye-piece) is inserted into this hole so that the service man may conveniently view a composite view of the frequency peaks on the film and the slit image on it from the front of the sound head. The latter may thus be focussed on and oriented with respect to the sound track. However, other methods for doing this are now employed, so that the usefulness of this illuminator is not particularly marked. (3) No exciter lamp ammeter or rheostat is furnished on the photocell housing of this sound head, as this head was furnished with equipment using an Input Control Panel, on which these units were mounted.

PS-14 and -16 SOUND HEADS — RCA PHOTOPHONE.

Figures 12 and 9 show a PS-16 and PS-14 sound head, respectively. The former is used for a Simplex projector and the latter for a Powers. The only difference between the two heads is in the method of mounting them on the pedestals and to their respective picture heads, and in the drive gear, which is located on the other side of the mechanism. As can be seen from either figure, the film feeds into a sound gate, thence over an idler roller directly beneath it, then it wraps around the free-running impedance roller and thence over the constant speed sprocket. A small loop is left between it and the take-up or hold-back sprocket, and from thence the film proceeds through the fire rollers to the lower magazine onto the lower take-up reel.

The constant speed sprocket is directly driven by a gear train from the motor, and no provision is made to smooth out any vibrations

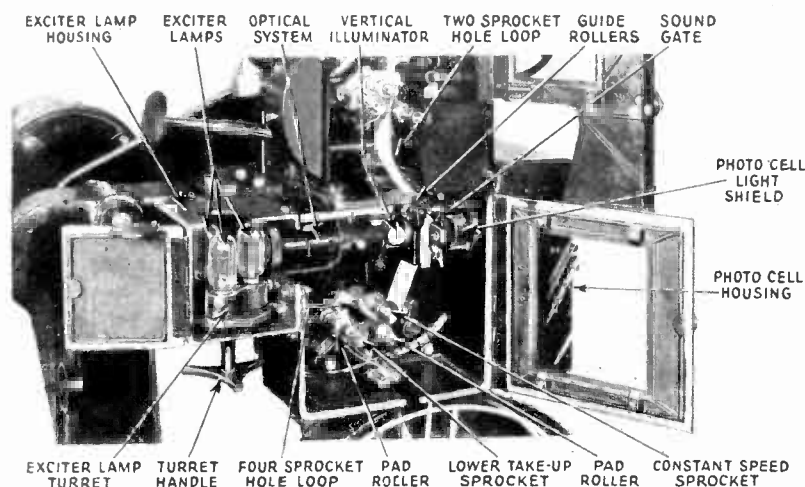


Fig. 8 - OPERATING SIDE OF TYPE PS-1 SOUND HEAD.

(from gears, etc.) that may be transmitted to it. However, between it and the sound gate is interposed the impedance roller, which prevents any of this vibration from being transmitted to the film in the sound gate, as described previously in this lesson. It must be remembered that on the rear of the impedance roller shaft (behind the center plate) is mounted a flywheel to give the requisite inertia to this roller.

In Figure 12 you will note that the motor is directly geared to the main drive shaft, instead of transmitting its motion through a chain, as in the PS-1 and 8 heads. The action, however, is exactly the same. In the case of the PS-14 head (for Powers) this main drive gear meshes directly with the sound head main drive gear, but drives the Powers picture head through a series of auxiliary gears, due to the different gear arrangement in this head.

The exciter lamp is mounted in a bracket instead of a turret. The lamp can be adjusted in the bracket for proper illumination of the

slit, and then the lamp and bracket removed, and another lamp adjusted in another bracket and used. When this second lamp burns out, the first lamp and bracket can be quickly substituted for the other, so that no appreciable interruption in the show need occur.

The optical system is somewhat different from that used in the other heads. A single condenser lens is at the rear of the lens tube (near the exciter lamp) instead of two lenses as in the other heads, and the slit is located very close to it. The slit may be rotated into proper alignment by means of a little lever protruding through the top of the lens tube. The objective lens (which is partly hidden by the sound gate) may be moved backward or forward for focussing by

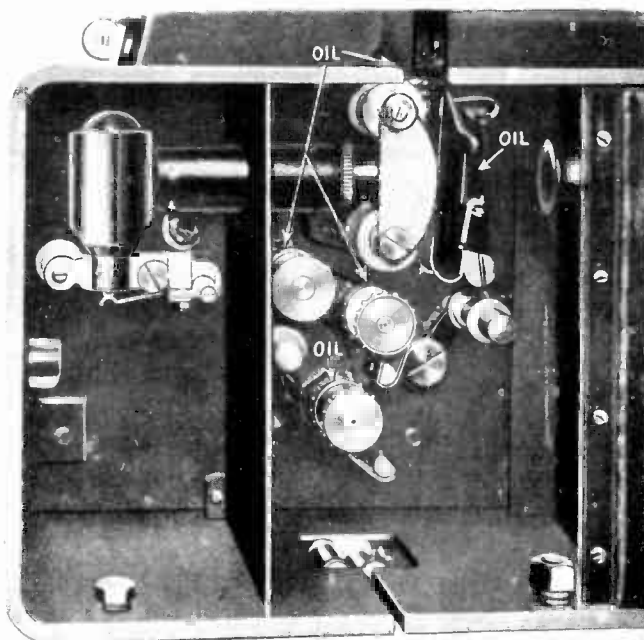


Fig. 9 - FILM SIDE OF TYPE PS-14 SOUND HEAD, SHOWING OILING POINTS AND EXCITER LAMP SHIELD IN PLACE.

turning the knurled ring, which causes it to screw in or out of the lens tube. A strip of metal bears down on this knurled ring, thus locking it sufficiently to prevent it from turning of its own accord.

The sound gate consists of a stamped metal guide plate, and a stamped metal tension pad, on which are mounted the two tension shoes, much like the runners on a sled. These hold the film firmly against the guide plate when the gate is closed. The two guide rollers may be moved sidewise in order to adjust the film laterally so that the entire slit falls on the sound track. In the other heads, you remember that the optical system was moved laterally to accomplish this.

In the PS-20 heads the arrangement is much the same as in the above, except that the constant speed sprocket is directly driven by a flywheel mounted on the other end of the shaft. The flywheel is in turn belt-driven from the motor by means of three V-belts. The photocell is inserted through a hand-hole at the top of its compartment instead

of through an opening in the side. Moreover, the photocell transformer has a secondary of 500 ohms impedance, to match the input transformer of the type PG-30 amplifier.

The PS-22 sound head is of simpler construction, and is used in conjunction with the PG-28 small theatre equipment. This sound head dispenses with the impedance roller, and the film is pulled through the sound gate directly by means of the constant speed sprocket. The latter is belt-driven by the motor through a flywheel, in order to insure constancy of speed.

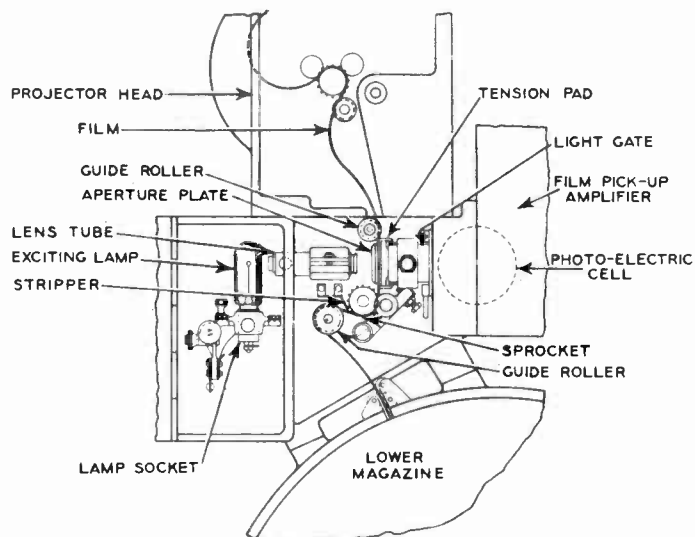


Fig. 10 - A TYPE OF WESTERN ELECTRIC SOUND HEAD.

The drawing in Figure 10 clearly illustrates the relation of component parts in a type of Western Electric sound head.

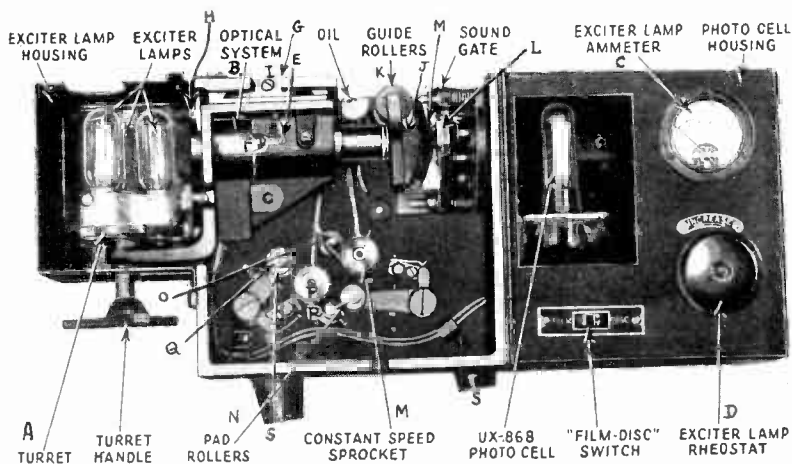


Fig. 11 - FILM SIDE OF TYPE PS-8 SOUND HEAD (PHOTOPHONE TYPES PS-5 AND 6 ARE SIMILAR).

This concludes the lesson on sound heads. In it we have studied various forms of this mechanism, and the functions which it performs. It is one of the most important parts of sound equipment, and upon its correct action depends much of the quality of the reproduced sound.

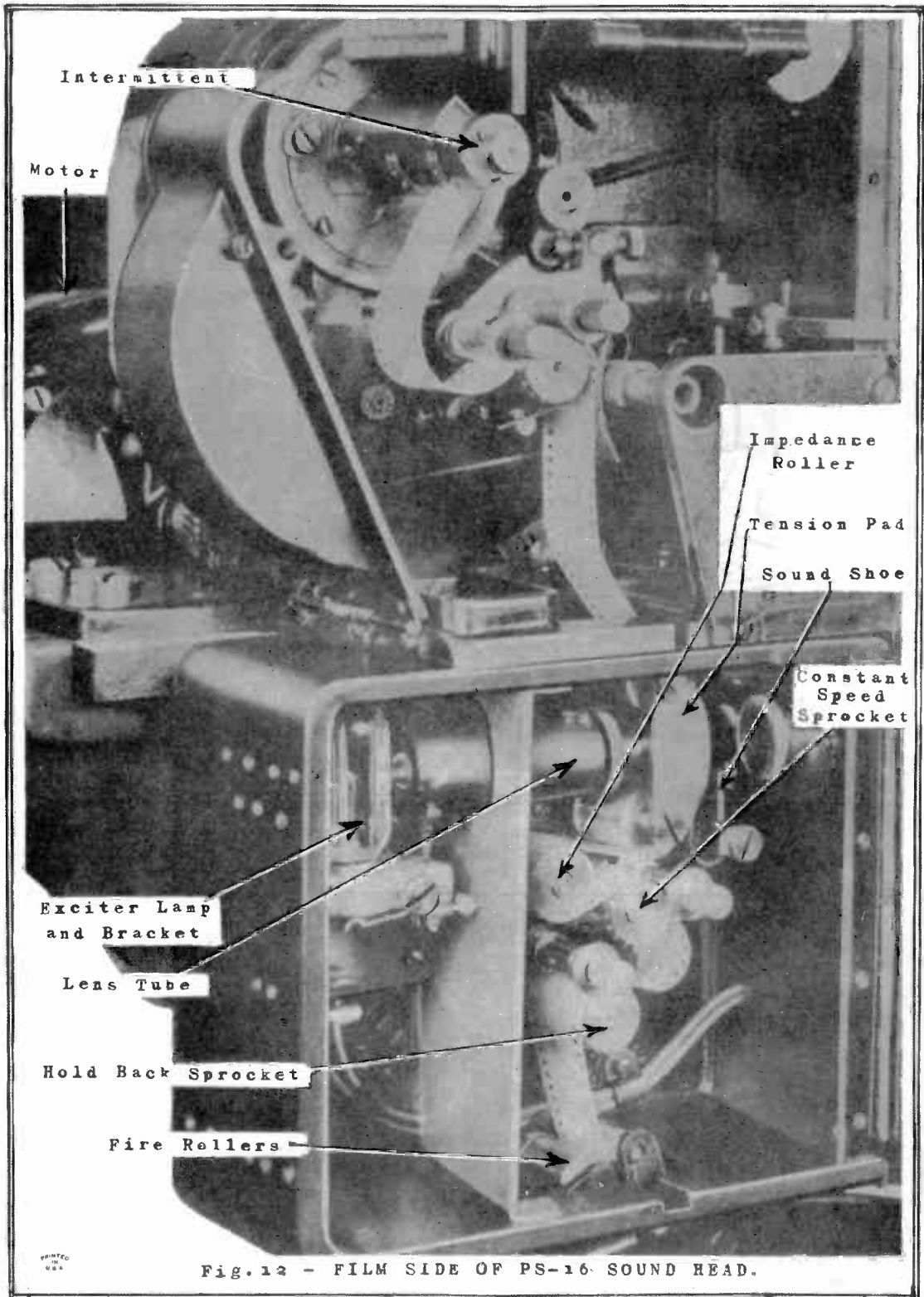
EXAMINATION QUESTIONS

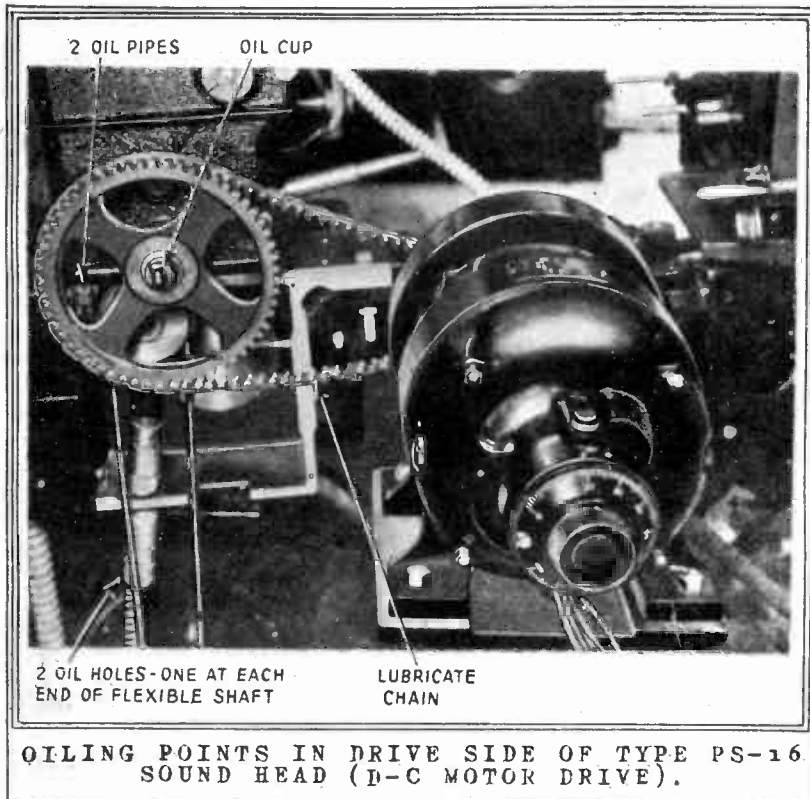
- 1 . What are the three fundamental parts of a sound head?
- 2 . (a). What is the purpose of the exciter lamp?  
(b). Of the optical system?  
(c). What is the purpose of the sound gate?  
(d). Of the constant speed sprocket?
- 3 . Why is it difficult to pull the film at a uniform speed?
- 4 . Explain the action of a viscous damped constant speed sprocket.
- 5 . Explain the action of the Western Electric drive for the constant speed sprocket.
- 6 . How does the impedance roller function?
- 7 . What is the purpose of the take-up or hold-back sprocket.
- 8 . What does the photocell do?
- 9 . Give two methods of coupling the photocell to the main amplifier.
- 10 . Why must the light slit be so fine in height?

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OILING POINTS IN DRIVE SIDE OF TYPE PS-16  
SOUND HEAD (D-C MOTOR DRIVE).