A NEWLY DESIGNED SOUND MOTION PICTURE REPRODUCING EQUIPMENT*

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Purpose of Design.—There have been many developments in Sound Equipment during recent years which were a long step forward in the short but lively history of sound-on-film. However, as time went on, subsequent investigations revealed that certain refinements could be made in these developments which, together with other new improved features, would give to the exhibitor appreciably better overall performance. It was to reach this end that the new RCA *PG-140* series of equipments were designed. A set of specifications was prepared which can be summarized as follows:

General

(*a*) Simplicity in design, good overall performance, serviceability, and standby facilities at reasonably low cost.

(*b*) All parts of the equipment shall have Underwriters' approval.

Sound Head

(*a*) Isolate constant-speed sprocket-shaft drive.

(*b*) Simplify method of mounting projectors to sound head.

(*c*) Employ separate gear box for drive gears.

(*d*) Use double exciter lamp socket with pre-focused lamps.

(*e*) Provide adequate static shielding for phototube circuits.

(*f*) Make provision for push-pull operation.

Sound Head Selector and Volume Control System

(*a*) Provide a simple, rugged, and positive sound head selector switch.

(*b*) It shall be possible to select any one of three sound heads from any projector station.

(*c*) Make provision for complete control of volume on front wall at each projector station; also, provision for pre-selection where desired.

Amplifiers and Power Supply Equipment

(*a*) Adequate power with low distortion in amplifiers, particularly at the lower frequencies.

(*b*) Reliable standby facilities in case of failure of main channel. This to be accomplished with as little additional equipment as possible.

(*c*) Tube metering facilities.

(*d*) Low ripple in power supplies, together with the use of high-quality parts, particularly in high-gain stages to effect a low overall noise level. Standby for these power supplies.

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** RCA Manufacturing Co., Camden, N. J.

(*e*) Provisions on loud speaker dividing network for taking amplifier response curves and for standby operation of loud speakers.

(*f*) Conservative rating of components and tubes for long life.

(*g*) All units to be in one or more racks as required.

Loud Speakers and Overall Response

(*a*) The loud speakers employed on all equipments shall be of such design that the response-frequency characteristic of the complete system (including sound head, amplifier, and these loud speakers) shall be comparable to that desired by the Committee on Standardization of Theater Sound Reproduction Equipment Characteristics of the Academy of Motion Picture Arts & Sciences.

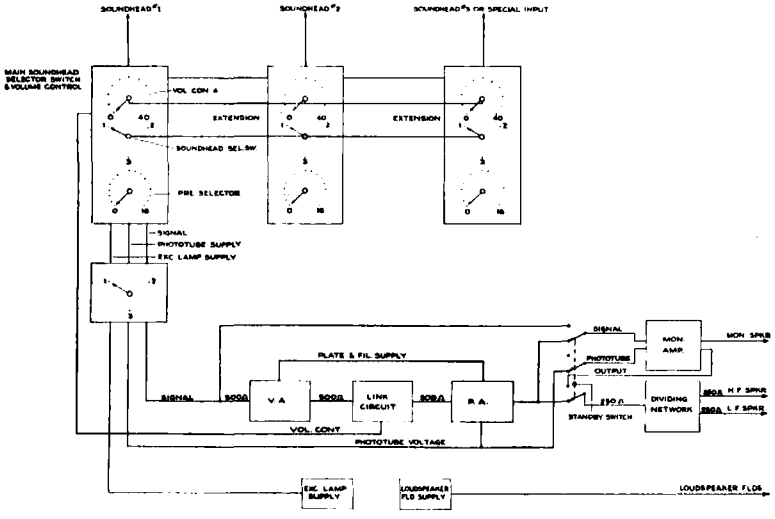

FIG. 1. *PG-140* block diagram layout.

(*b*) The design of the horns shall be such that proper distribution of both high and low frequencies can be obtained.

(*c*) The driving mechanisms shall be high enough in efficiency to produce an adequate sensation level without objectionably overloading or requiring the undistorted output of the amplifier to be exceeded. This shall hold at all frequencies within the desired range.

(*d*) Provide suitable monitor speaker.

Styling

(*a*) Each of the units making up this equipment shall be designed for good appearance and uniformity in resemblance. This styling shall be consistent with function.

GENERAL LAYOUTS

(*1*) *PG-140 Equipment, 25 Watts.*—Fig. 1 is a block diagram of the *PG-140* equipment. Starting at the sound heads, their respective outputs are brought to the main sound head selector switch and volume control box shown on the left-hand side of this diagram through pre-selector pads, if they are used. From this box, the signal of the sound head selected is conducted to the special input selector switch, if it is employed. From the special input switch, the signal is carried to the input of the voltage amplifier and a standby switch which is mounted on the monitor amplifier chassis, then to the 25-watt power amplifier through the link circuit, then on to the dividing network, and finally to the loud speakers, which

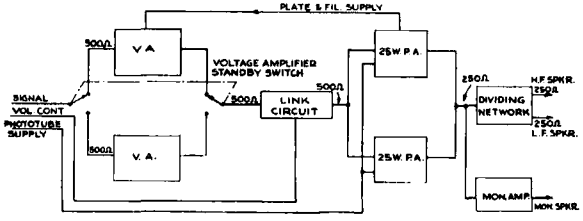

FIG. 2. *PG-141* block diagram layout.

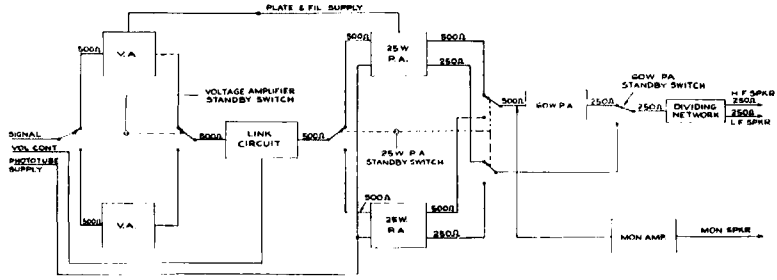

FIG. 3. *PG-142* block diagram layout.

consist of a high- and low-frequency horn with two mechanisms on each. Complete control of volume on the front wall is obtained by a variable *T*-pad which is connected in the link circuit between the voltage and power amplifier. In the position shown for the standby switch, which is its normal one, the monitor amplifier is bridged across the output of the 25-watt power amplifier. In the standby position, the monitor amplifier is bridged across the input of the voltage amplifier with its output replacing the output of the power amplifier across the input of the divider network. By further action of this switch in its standby position, a bleeder circuit in the monitor amplifier furnishes phototube polarizing voltage. The monitor amplifier is thus made to serve as a standby amplifier.

A switch on the exciter lamp supply provides a-c standby for the exciter lamps. Standby field supply is obtained from the arc generators through the use of a switch installed at the time of installation. Loud speaker standby is effected by a switch on the dividing network.

(2) *PG-141 Equipment, 50 Watts.*—Fig. 2 is a block diagram of the *PG-141* equipment. This equipment is the same as the *PG-140*, with the exception that two voltage and two 25-watt power amplifiers are employed and standby is accomplished in a little different manner. Either of the voltage amplifiers may be used depending upon the setting of a standby switch. In case of failure of one of

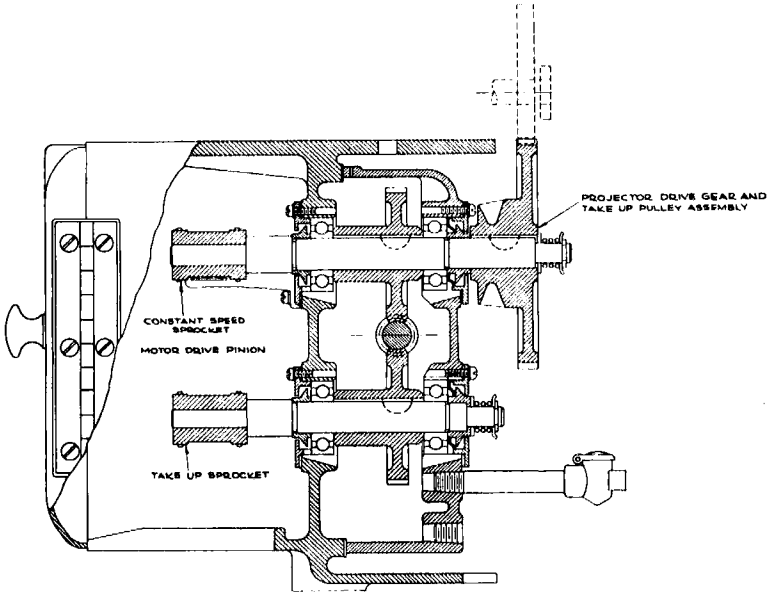

FIG. 4. Old gear drive.

the power amplifiers, the output would drop slightly, but a sound outage would not occur unless the voltage amplifier receiving power from the power amplifier that failed was in use, in which case it would only be necessary to throw the standby switch to the other voltage amplifier. Thus complete standby of both voltage and power stages is accomplished.

(3) *PG-142 Equipment, 60 Watts.*—(Fig. 3.) This is the largest standard size equipment. It is similar to the *PG-141* with the exception of the addition of a 60-watt P. A. and its associated equipment.

Three standby switches are employed, giving two complete channels up to the 60-watt power amplifier and permitting the output to be taken from either of the 25-watt power amplifiers in case of failure of the 60-watt unit.

Although this equipment is rated at 60 watts, as compared to 50 watts for the *PG-141*, there is considerable difference in usable output due to the difference in shape between the respective distortion curves. This will be discussed later.

DETAILS OF DESIGN FEATURES

Isolated Constant-Speed Sprocket Drive.—In earlier type sound heads, the gear and pulley assembly, which drives the picture head and take-up mechanism, was keyed to the opposite end of the same shaft on which was mounted the constant-speed sprocket. This is shown in Fig. 4. Hence, any variations in load, from

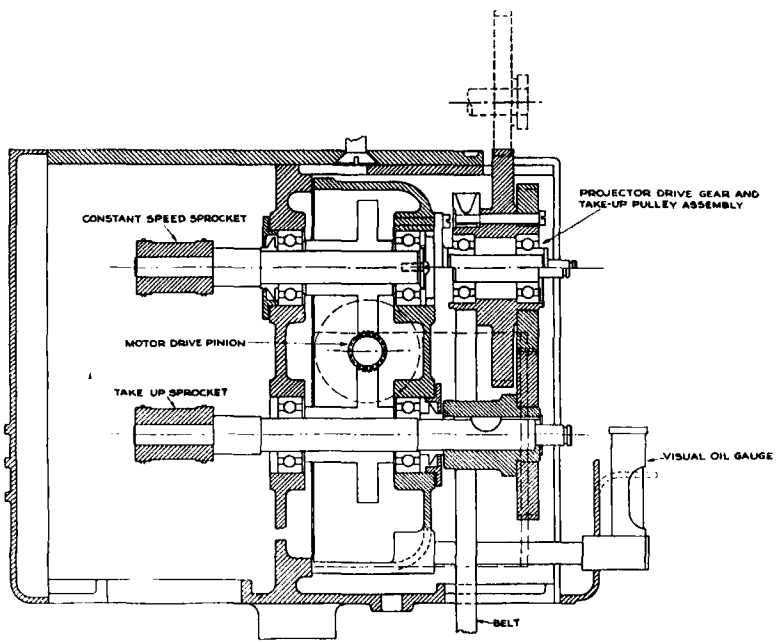

FIG. 5. New gear drive.

the sources just mentioned, affecting this assembly resulted in a corresponding variation in speed of the constant-speed sprocket.

In the new sound head, this arrangement has been changed so that the gear and pulley assembly in question is no longer a part of the constant-speed sprocket-shaft assembly, as can be seen in Fig. 5. To accomplish this two spiral gears were added in the following manner: The gear end of the constant-speed sprocket shaft was shortened and terminated in a cap which acts only as a supporter member. The take-up sprocket's shaft, however, has been lengthened and one of the new spiral gears has been keyed to this extension. This spiral gear meshes with the second one which has been directly attached to the projector head drive

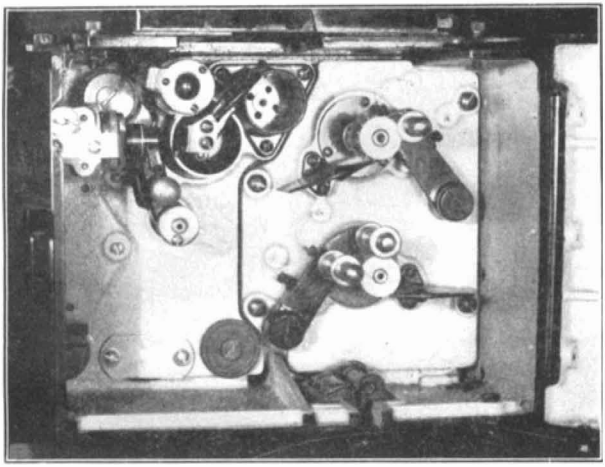

FIG. 6. Front view of new gear box mounted in place.

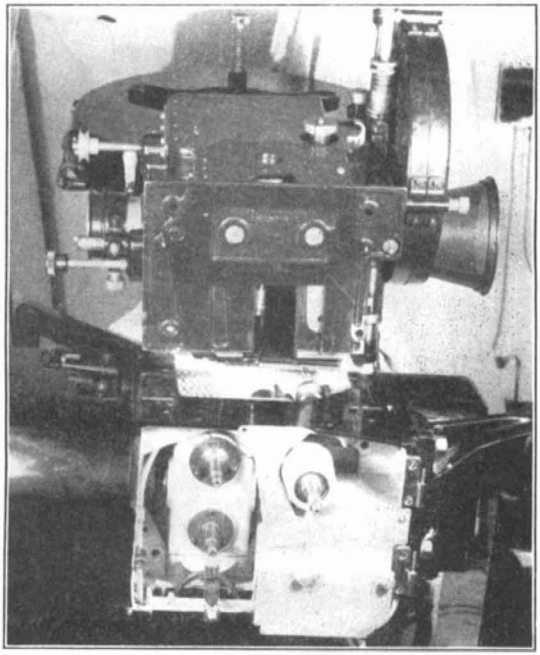

FIG. 7. Showing oil collection and projector adaptor plate mounted to bottom of projector head, the pins in the bottom of this plate, and the slots in the top of the sound head in which the pins fit.

gear and take-up pulley assembly. This new assembly rotates on a stationary study which projects from the back of the gear case housing.

Thus, it is evident that with this new arrangement, the varying loads from the take-up and projector mechanisms are transmitted to the take-up shaft to a much greater extent than they are to the constant-speed sprocket shaft. This is true because these variations can not readily go from the lower spiral through the motor pinion to the upper spiral due to the steep angle of these gears. Comparative measurements have shown a reduction in flutter.

Separate Gear Box.—The box for this new drive gear mechanism is assembled in a single unit and is removable as such (Fig. 6).

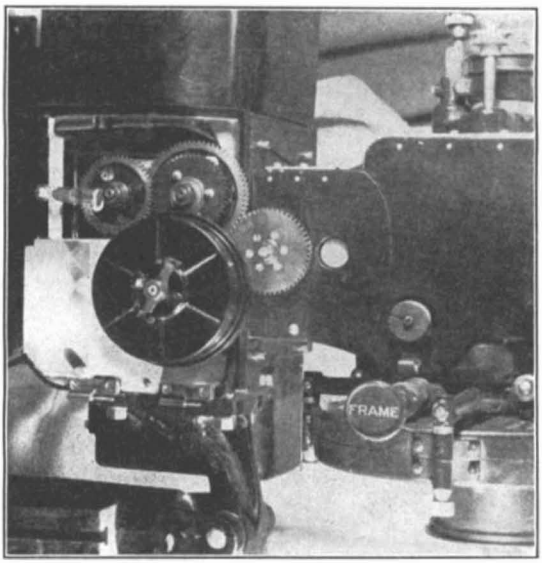

FIG. 8. Completed mounting of projector head oil collection and projector adaptor plate and sound head. Allen screws which hold the sound head to the projector adaptor plate can also be seen.

Projector Head Mounting Plate and Oil Collection System.—Another important feature of this new sound head is the simplification made in the method of mounting the projector head to the sound head and facilities for collecting excess oil.

With the new design, a separate $^1/_4$-inch thick mounting plate is attached to the bottom of the picture head by means of two $^8/_8 \times 16$ flat-head machine screws, which engage the two tapped holes in the bottom of the picture head as shown in Fig. 7. With this mounting plate securely attached to its base, the projector head is set upon the top of the sound head so that the three pins which project from the bottom of this plate are engaged with three corresponding slots in the top of the sound head. These pins and slots are also shown in Fig. 7. It is to be noted that it is not necessary to remove any parts from the sound head in

order to complete the assembly. The mounting plate is attached to the top of the sound head by four Allen head screws, with a plate and a shakeproof washer under the head of each. The completed mounting is shown in Fig. 8.

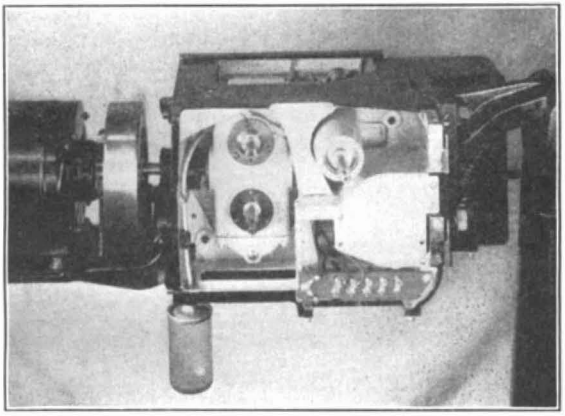

FIG. 9. Showing oil tube which conveys excess oil from this plate to the receptacle on the bottom of the sound head.

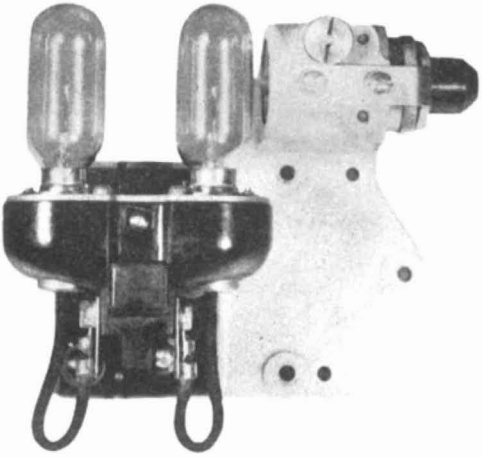

FIG. 10. Dual exciter lamp socket mounted in position with pre-focus lamp.

As can be seen from Fig. 7, two of the pins in the bottom of the mounting plate engage two slots which are parallel to the operating side of the sound head. These pins working in their respective slots permit motion toward or away from

the screen, without permitting lateral motion. The slot in which the third pin engages is at right angles to the other two slots. This third pin is mounted on the plate eccentrically with relation to a large hexagon-headed cap screw. As this hex-headed screw is rotated, the complex picture head mechanism is moved either toward or away from the screen so that exact mesh of picture head drive gears may be readily accomplished.

In addition to acting as a picture head mounting plate, this same member acts as an oil-collection plate. Cast into its upper surface are a series of depressions

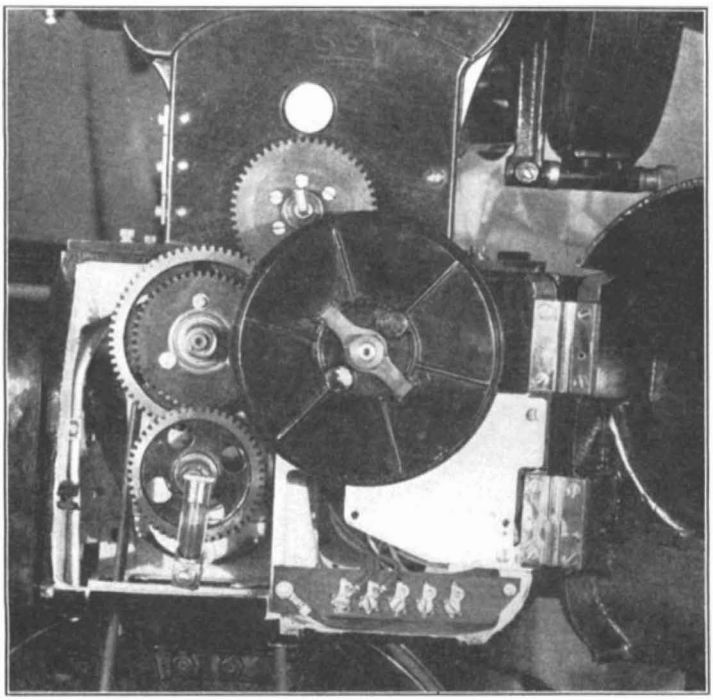

FIG. 11. Good accessibility to the photocell terminals.

into which the oil drips from the edges of the picture head. From this point the oil drains into a transparent removable receptacle (Fig. 9).

This receptacle is not screwed to the end of the $^1/_4$-inch tube but instead mounts to the bottom of the sound head. This permits any excess oil in the bottom to drain into the receptacle through the same hole that the drain tube passes through.

Double Exciter Lamp Socket with Pre-Focused Lamps.—The new double exciter lamp socket with its mounting as shown in Fig. 10 is illuminated and the lamp which was originally in operation is not lit. This socket, in conjunction with the pre-focused lamps, makes it possible to very easily and quickly effect a re-

placement. In case of a burn-out of the operating lamp the double lamp socket is removed, rotated 180 degrees, and reinserted, electrical contact being automatically established to the lamp adjacent to the lens barrel. Neither vertical nor horizontal adjustment is necessary. Prefocused lamps are used.

Statically Shielded Phototube Circuit, Including Socket, Leads, Terminal Board and Transformer.—In the new sound head, the transformer is mounted in sponge rubber in an enclosed cast-iron chamber. The phototube socket, leads therefrom to the transformer, and the terminal board are also statically shielded in a cast-iron channel and suitable metal covers.

The terminal board is readily accessible for inspection by swinging the hinged gear cover out of its normal position and removing a small sheet-metal cover as illustrated in Fig. 11.

Styling.—The results of modern styling are shown in Fig. 12. This has merit

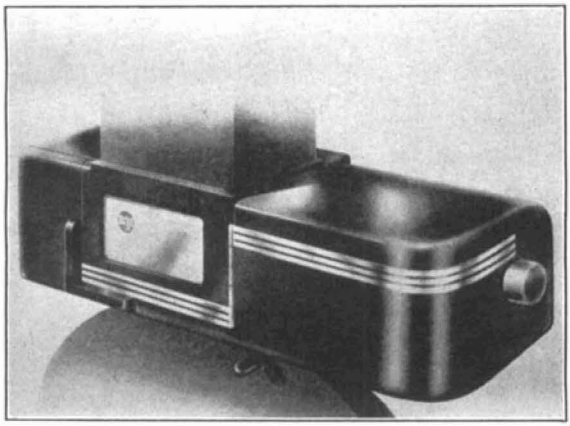

FIG. 12. Style view of sound head.

for display purposes, and it is also felt that it is conducive to better operation, servicing, and maintenance.

Sound Head Selector and Volume Control System.—It is possible to select the output of any sound head from any projector station for a three-projector installation, as well as for one having only two projectors. This is accomplished simply, conveniently, and at low cost by the use of extension rods. To meet the requirement that all controls should be front-operated, the associated operating knobs were coupled to these rods by miter gears.

"Mercury Kon-nec-tors" Employed in Selector Switch.—The sound head selector switch used in this new series of equipment is of the "Mercury Kon-nec-tor" type which has contacts sealed air-tight in glass tubes. Permanently low contact-resistance is assured, and the necessity for cleaning contacts is eliminated. In addition, all projectors or other input sources are connected in series. Those not being used are short-circuited by the mercury contact. In this way, even if a contact should fail to close, a completely closed circuit is still

available to the input of the amplifier (Fig. 13). The only indications of a failure would be a drop in level and possibly noise from the unused projector.

A maximum of three projectors is provided for on this switch. If only two projectors are used, the third position may be used for "Special Input." If three projectors are employed, a separate switch of the same type is available to be used in addition to the one just described, which connects one of the three sound heads previously selected or one of two other inputs to the voltage amplifier.

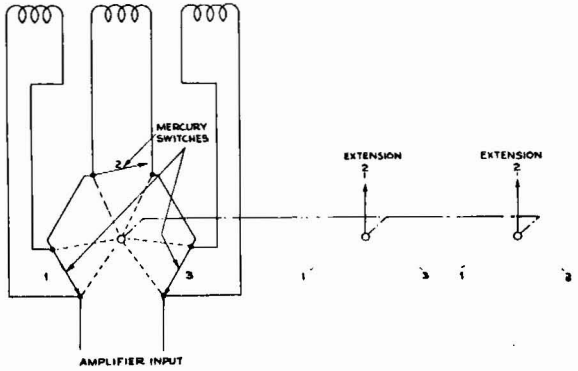

FIG. 13. Schematic of input circuit.

Either one of the two input sources not being used can be selected by throwing the switch through 120 degrees. A suitable detent is employed to insure positive action and the mercury tubes are cam-operated into short- or open-circuit position as required.

Complete Control of Volume on Front Wall at Each Projector Station.—The design employs a 500-ohm link circuit between the voltage and the power amplifier. This link circuit accommodates a 20-step 500-ohm *T* attenuator.

FIG. 14. *MI-9701* and *MI-9702* coupled by *MI-9703*.

The first fifteen steps of this pad are 2 db each, and the last four steps are progressively larger, being 4, 4, 6, and 9 db, respectively. There is also an off step which gives infinite attenuation. As this pad operates at a level which is 55 db above the input circuit, it can be placed on the front wall without danger of the effects of pick-up from stray fields. It can be controlled from any projector station by extension rods.

It is housed in the same box with the sound head selector switch but suitably shielded from the latter to prevent coupling. Also housed in this box is a network for controlling the polarizing voltage to the phototube and further space is provided for a second network for push-pull operation.

Provision for Volume Pre-Selection.—In addition to these parts, it is possible to install in this box a 16-db variable *T*-pad attenuator for volume pre-selection. This pad connects in the link circuit between the sound head and the voltage amplifier. This unit is not supplied as standard equipment.

The box which houses these parts constitutes the main sound head selector switch and volume control. It is commonly termed the "Main Fader." This main control unit, together with the extension unit and extension rods, are shown physically in Fig. 14. The interior construction of the main control unit and mercury selector switch is shown in Fig. 15.

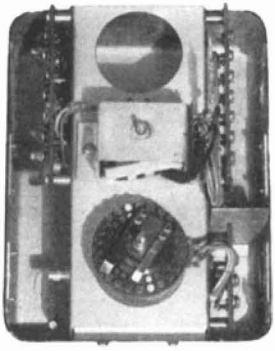

FIG 15. Interior of *MI-9701* showing mercury switch assembly and one of the mercury contacts.

Amplifiers and Power Supply Equipment

Voltage Amplifier.—The voltage amplifier employed in this equipment is a two-stage amplifier, using *RCA-1620* tubes as resistance-coupled pentodes in both stages with 18-db degenerative feedback on the second stage. Filament and plate power are both obtained from the 25-watt power amplifier with which it is associated. Its electrical characteristics are as follows:

Input Impedance 250 or 500 ohms
Load Impedance 250 or 500 ohms
Frequency Response ±1 db from 30 to 10,000 cycles
Gain 55 db
Maximum Output Level +6 db (0.006 w. ref.)
Output Noise Level −75 db (0.006 w. ref.)

25-Watt Power Amplifier.—The power amplifier consists of three stages, using one *RCA-1620* as a pentode in the first stage, one *RCA-1620* as a triode in the second stage, with a third *RCA-1620* operated as a triode phase inverter. The last stage is a parallel push-pull stage, using four *RCA-1622* tubes which are special tubes similar to the *RCA-6L6*. Two *RCA-5U4G* rectifiers provide the plate supply. In addition, one *RCA-874* regulator tube is used to regulate the polarizing voltage for the phototube which is taken from this amplifier. Inverse feedback is employed in the last two stages to reduce the distortion at all output values below maximum. It does not increase the maximum output of the amplifier, however. A second feedback circuit is employed on the first stage to increase its output, so that there will be sufficient margin between the undistorted output of the first stage and the required input to the second stage.

A plate current meter is supplied on the front panel of this amplifier which may be switched to measure individually the plate current of each of its tubes or to measure the combined plate currents of the tubes in the voltage amplifier.

The electrical characteristics of this amplifier are as follows:

Input Impedance 250 or 500 ohms
Load Impedance 7.5, 15, 250, or 500 ohms
Frequency Response ±1 db, 30 to 10,000 cycles
Gain 67 db
Rated Output at 2% Distortion (50 to 5000 cps) 25 watts (0.006 w. ref.)
Maximum Output 50 cps 33
1000 cps 38
5000 cps 36
Output Noise Level −55 db (0.006 w. ref.)

60-Watt Power Amplifier.—The 60-watt amplifier is panel mounted, with the following electrical characteristics:

Source Impedance 500 ohms
Input Impedance 500 ohms
Load Impedance 250, 30, 15 ohms
Rated Output 60 watts at 2% distortion (50 to 5000 cps)
Maximum Power Output 100 watts at 50 cycles
140 1000
132 5000
Gain 15 db
Frequency Response ±1 db, 30 to 10,000 cycles
Noise Level 135 db (0.006 w. ref.)

The tubes used are two *RCA-845*'s and two *RCA-866-A* rectifiers. Two separate plate current meters are provided, one in each of the amplifier tube cathode circuits. Since the rectifier tubes are of the mercury vapor type, and the filaments must be heated for thirty seconds before applying plate voltage, a manual time delay switch is provided on the front of the rack for this purpose. This switch will be connected so as to control all the amplifier and power supply equipment in the entire three racks, by means of the inter-rack wiring. A safety switch is provided to shut off the plate voltage, in case the front cover is removed from the rack, for the protection of those working on the equipment.

Monitor and Standby Amplifier.—The monitor amplifier is a three-stage unit with 16 db of feedback on the last two stages. Two *RCA-1620*'s are used in the first two stages, and one *RCA-1622* in the output stage. One *5Y4G* tube supplies plate voltage and an *RCA-991* is used as a regulator on the phototube polarizing voltage supply.

When used as a monitor amplifier, the input is connected across the output of the main amplifier through an 86-db *L*-pad. As previously described, when the standby switch is thrown to the standby position, the input and phototube polarizing voltage supply are paralleled across the corresponding circuits on the main amplifier, in order to avoid breaking the circuits of the main amplifiers. It is, however, necessary to break the output circuit of the main channel to switch the input of the loud speaker dividing network from the main channel to the standby amplifier. This is all accomplished by the standby switch which mounts on this amplifier chassis. The monitor speaker remains connected to the monitor amplifier at all times, and so functions as a monitor under either condition. The volume control on the front wall is inoperative when the standby channel is

being used. Under this condition, the grid type volume control on the monitor amplifier is used.

It is felt that this feature is one which has considerable merit, particularly when cognizance is taken of the fact that the amplifier is normally required to serve only one purpose but by a judicious choice of circuits was made to give a dual service which is definitely desired.

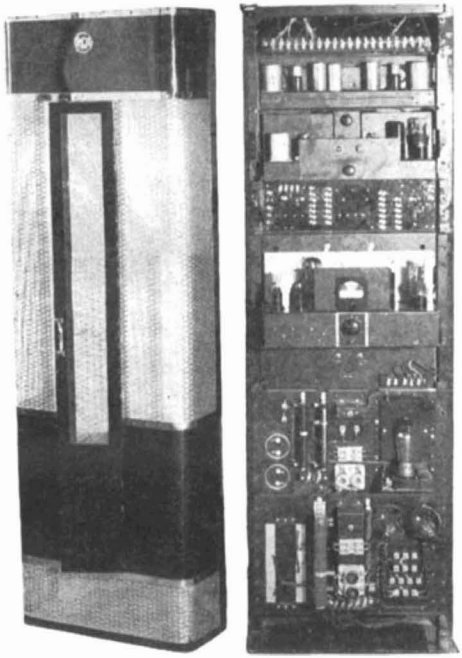

FIG. 16. *PG-140* amplifier rack cover for showing arrangement of units from top to bottom.

This amplifier has the following characteristics:

Input Impedance	unloaded transformer
Load Impedance	15 or 250 ohms
Frequency Response	30 to 4000 cycles + or − 1 db, 4000 to 8000 cycles +0–5 db
Gain	105 db
Feedback	16 db
Output	6 watts at 5% distortion
Noise Level	−20 db (0.006 w. ref.)

Loud Speaker Dividing Network.—The network used with this series of equipment is of the *M*-derived type, designed for input and output impedances of 250 ohms. A high-impedance line was decided upon because a more convenient

arrangement of parts could be effected and line losses are materially reduced. While it probably would have been a little more desirable to standardize on a 500-ohm line, this could not very well be done because of the problem of wire size and insulation consistent with Underwriters' requirements, together with the dangers involved of exposing service engineers to high voltages. Moreover, the impedance decided upon is one which is widely used.

A standby switch is provided on this network by which the projectionist can switch the full output of the amplifier into the low-frequency speakers, in case of

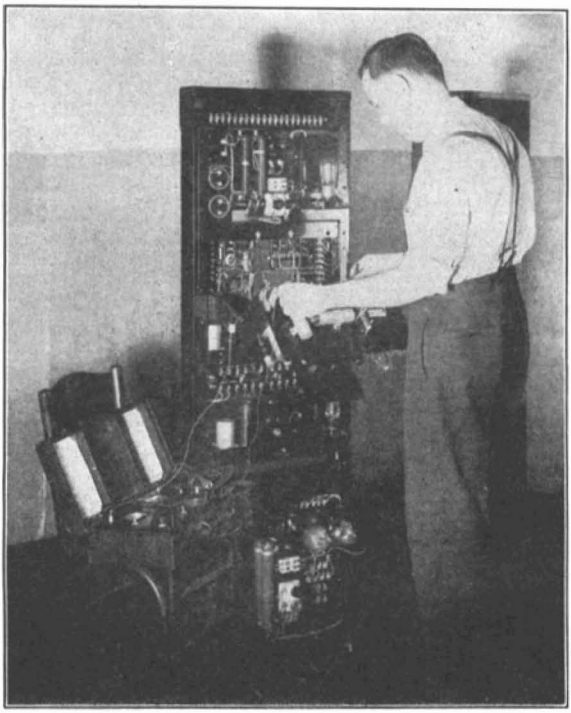

FIG. 17. *PG-140* rack cover off showing hinged construction of necessary components for accessibility.

failure of the high-frequency speakers or any part of the network. A second switch is also provided to permit the service engineer to substitute a self-contained resistor load in place of the speakers for checking the frequency characteristic of the equipment. A jack is provided by which he can plug a power-level meter into the circuit across the resistor load.

Loud Speaker Field Supply.—The power-supply unit for the loud speaker fields utilizes a full-wave mercury vapor rectifier tube (G.E. cat. *16X897*). This unit supplies a maximum of 1.5 amperes at 120 volts, d-c, or enough power for six loud

speaker fields. The ripple voltage is −54 db (0.25 v) below a 1.5-ampere load at 120 volts with a 60-cycle input.

Exciter Lamp Supply.—The exciter lamp supply employs two *RCA-2000* tubes, which are similar to 6-ampere Tungars and Rectigons, in a full-wave circuit. It supplies 9.0 amperes at a maximum of 12.0 volts for two 10-volt, 5-ampere exciter lamps operating in parallel at a reduced rating of 4.5 amperes. The ripple voltage is −62 db (0.01 volt) below its output voltage at rated load with a 60-cycle input. The regulation of this unit is such that if one of the exciter lamps burns out or is disconnected, the second will not burn out due to a greater supply voltage, nor will the volume of the operating machine be objectionably increased.

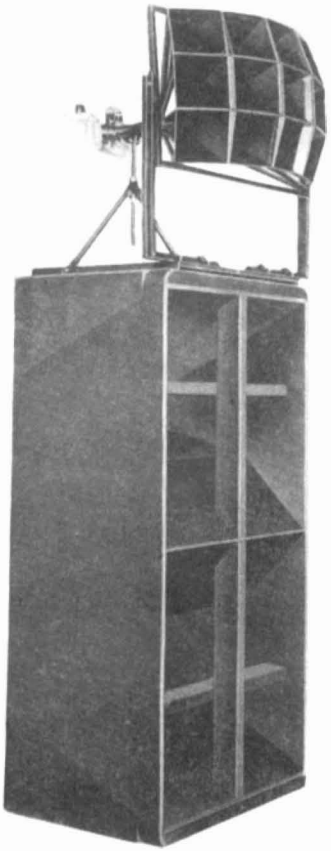

FIG. 18. *PG-140* speaker complement.

A standby switch supplies raw a-c taken direct from the power transformer.

PG-140 Amplifier and Power Rack.—The components of the amplifier and power rack for the *PG-140* equipment are arranged from top to bottom in the order shown in Fig. 16: (*1*) Voltage amplifier, (*2*) monitor amplifier, (*3*) link circuit, (*4*) 25-watt power amplifier, (*5*) loud speaker divider network, (*6*) field supply, (*7*) exciter lamp supply.

Fig. 17 shows how the necessary components have been hinged for good accessibility in servicing and inspection.

PG-141 Amplifier and Power Racks.—These racks are constructed similarly to the one employed for the *PG-140* equipment, but owing to the additional units used, two racks are required. All parts of the main amplifier are mounted on one of these racks as follows, in order from top to bottom: (*1*) Voltage amplifier, (*2*) standby switch, (*3*) voltage amplifier, (*4*) link circuit, (*5*) 25-watt power amplifier, (*6*) 25-watt power amplifier.

The second or power-supply rack used in this equipment mounts the following units: (*1*) Monitor amplifier, (*2*) loud speaker divider network, (*3*) exciter lamp supply, (*4*) field supply.

All the above units are the same as used in the *PG-140* equipment, with the following exceptions: The standby switch used on this equipment is mounted on a separate panel, and is a four-pole double-throw toggle switch. The monitor amplifier is not equipped with a standby switch, and is not used as a standby amplifier.

PG-142 Voltage and Power Amplifier Racks.—This equipment is similar to the *PG-141* equipment, with the addition of a third rack for supporting the 60-watt class *A* power amplifier with the other associated units.

Although this equipment is rated at 60 watts, as compared with 50 watts for the *PG-141*, there is considerable difference in usable power output, as shown by comparison of the 2-per cent ratings to the maximum power output ratings. Maximum power output of the *PG-141* amplifier at 1000 cycles is 76 watts (two 25-watt power amplifiers in parallel) as compared with 140 watts' maximum power output of the *PG-142* amplifier at the same frequency.

Where desired, a second 60-watt power amplifier can be employed increasing the amplifier capacity to 120 watts. When this second amplifier is added, the equipment is known as the *PG-143*. However, with this increase in power out-

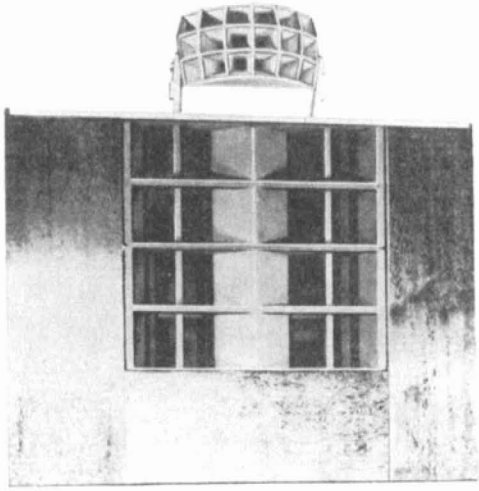

FIG. 19. *PG-141* and *PG-142* speaker complement.

put, a change in speaker complement, together with other desirable changes are recommended and, consequently, no standard schedule has been prepared. Instead, each case requiring such equipment will be treated separately.

Conservative Rating of Components and Tubes for Long Life.—All materials and parts used in these equipments are of the highest quality available. High-quality parts alone, however, will not give satisfactory and lasting service, unless properly used. Every effort has been made to see that all parts are used only under conditions conducive to long life.

Electrolytic capacitors were employed only after thousands of hours of test of representative samples at full rated values. In these equipments, they are employed under conditions of applied voltage, a-c ripple, and temperature which are well under the rated values.

By very close coöperation with the tube manufacturer, tubes have been obtained for this equipment which under the conditions of operation will have a life of several thousand hours. All the tubes used are specially selected and controlled in production for characteristics important in this particular application. The standard equivalents of these tubes can be substituted where necessary with a corresponding reduction in life and lower overall performance.

Underwriters' Approval.—All parts of these equipments have been submitted to the Underwriters' Laboratories for test and examination and have been approved.

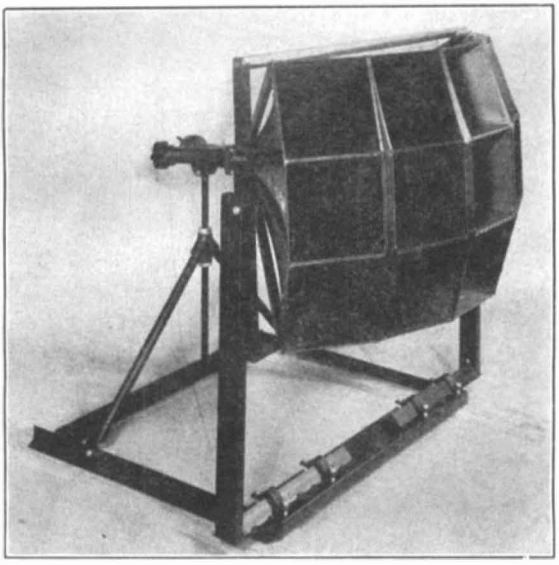

FIG. 20. High-frequency horn-mounting bracket.

LOUD SPEAKERS AND OVERALL RESPONSE

Loud Speaker Equipment.—The loud speaker complements employed with the *PG-140*, *PG-141*, and *PG-142* equipments are shown respectively in Figs. 18 and 19. The larger complement, shown in Fig. 19, is used on both the *PG-141* and *PG-142* equipments.

Distribution.—As can be seen in Fig. 18, the low-frequency baffle is mounted on its end to permit better low-frequency distribution in the horizontal plane.

New High-Frequency Horn-Mounting Bracket.—As a further aid to readily obtaining equal high-frequency distribution in the theater, a new high-frequency horn-mounting bracket has been designed. This mounting bracket is shown in Fig. 20. It will be noted that this bracket pivots the high-frequency horn about the center layer of cells and is sufficiently close to their mouth that the horn can be angled up or down without seriously changing its phase relationship with

the low-frequency baffle. This operation is facilitated by a screw adjustment on the rear support.

Overall Response.—While it has not proved generally practicable to make sound-pressure measurements in theaters, extensive listening tests show that satisfactory overall results are being obtained.

Conclusions.—Consideration of the foregoing will show that the specifications described herein have been met in detail. This is substantiated by the performance this apparatus is giving in service. It is consequently felt that a very definite step has been made in the progress of sound motion picture reproducing equipment. The author wishes to acknowledge the practical contributions received from many members of the motion picture industry and also, the personnel of the sales, service, and engineering divisions of the RCA Manufacturing Co., Inc., which were of material aid in the design of these equipments.

A HIGH-INTENSITY ARC FOR 16-MM PROJECTION*

H. H. STRONG**

Present-day application has lifted 16-mm projection from the strictly portable classification to that of permanent installation in theaters where newsreel service is supplemented with local coverage; in classrooms, since more extensive film service is available and where safety is an important factor; and in large auditoriums where lectures are illustrated by personal film.

However, where large screens are used, it is necessary to employ the high-intensity arc as a light-source to secure a picture brilliancy and color that is at all comparable to theater projection.

To that end has been developed a high-intensity arc which will project approximately 1000 lumens of light with the projector running. This is sufficient light to project a picture up to sixteen feet in width, with the white-light characteristic of the high-intensity arc. This is approximately three times the light secured with a 750-watt commercial Mazda projector.

In designing a high-intensity arc for 16-mm projection, the limiting factors have been film damage due to aperture heat; the burning time without retrimming; the lamp current consumption; optical speed; physical dimensions and weight; simplicity of operation; safety; costs; and Underwriters' requirements for non-theatrical use.

By experimentation, it was determined that a 30-ampere high-intensity arc produced the maximum amount of light that could be projected without buckling the 16-mm film, even though protected by heat-absorbing filter and air-blast.

Since 50 minutes is the running time of a 400-foot 16-mm sound-reel, a carbon burning time of one hour without retrimming was established.

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** Strong Electric Co., Toledo, Ohio.