MODERN PROJECTION EQUIPMENT

B T-H

THE
BRITISH THOMSON-HOUSTON
COMPANY, LIMITED
RUGBY, ENGLAND

G.12,005

MODERN PROJECTION EQUIPMENT

with special reference to

BTH Single Unit Projection Assembly—S/U/P/A

and

BTH Supa—Mark 2

CONTENTS

This publication is primarily intended for the assistance of projectionists and cinema technicians, in particular for those attending special instructional courses.

Many of the illustrations here reproduced appeared originally in SOUND-FILM PROJECTION *(George Newnes, Ltd.) and the compilers are indebted to the editorial staff of that invaluable textbook for their courteous co-operation.*

The BRITISH THOMSON-HOUSTON Co., Ltd.

RUGBY, ENGLAND

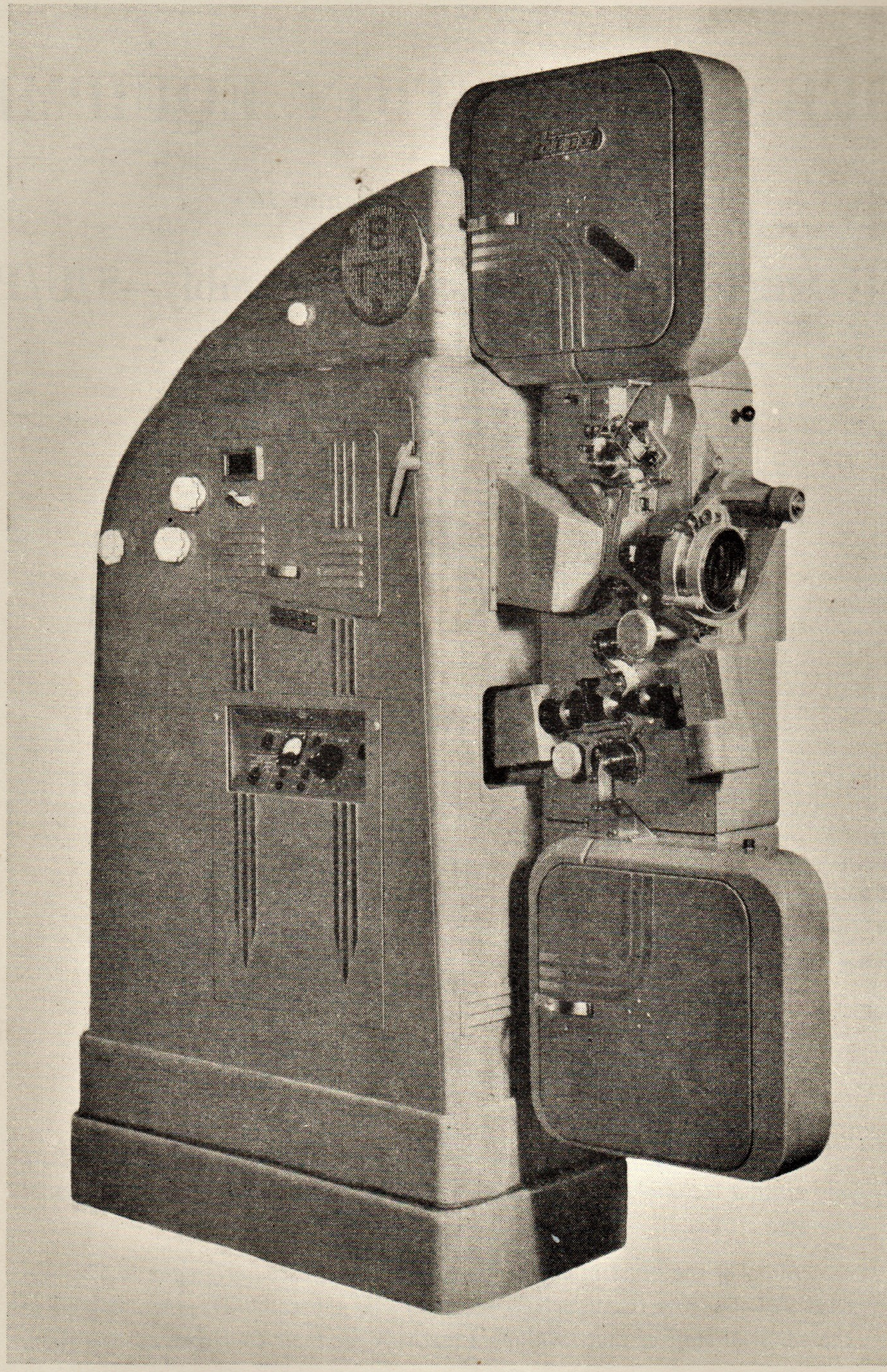


Fig. 1. Single Unit Projection Assembly—S/U/P/A.

As continual efforts are made to improve design, some equipments already installed may differ in detail from those illustrated.

MODERN PROJECTION EQUIPMENT

INTRODUCTION

THE progress of civilization depends to a great extent on advancements in scientific research, the growth of technical knowledge, and improvements in craftsmanship. There is, therefore, a continuous healthy striving to produce something new and something better than has been made before. Even so, there is a limit to the rate at which new ideas and improvements in design and manufacture can be introduced, for a wide diversity of interests must march along together—standards of living, education of the public, scientific discovery, and financial resources all play their part in determining the right time for the introduction of improvements and new designs.

Particularly is this so in the case of the cinema industry which has grown to such proportions that it now has a considerable influence on the daily life of the nation. The driving force behind the efforts to introduce new features and advances in cinema equipment is the ever-present demand by the public for the highest standard in the presentation of their entertainment.

The advent of sound-films provided a great stimulus to the expansion of the cinema industry and the improvement of projection equipment ; modern equipment is the result of co-ordinated effort by the engineer, the physicist and the chemist, each of whom is dependent on the others. For a classic example of this, it is only necessary to consider the projector lantern. At one stage of its development, the engineer was unable to meet the demand for more light from his lantern till the chemist could produce a more efficient carbon ; but when at a later stage the chemist introduced a new and much-improved carbon, a new lantern had to be designed before full advantage could be taken of its potentialities.

During the War years British manufacturers were unable to do any work on the design of cinema equipment ; in fact, the manufacture of such equipment was brought to a standstill, except where necessary for Service requirements.

When it became possible in 1946 to resume work on cinema equipment, the outstanding developments that had taken place during the war in electronic engineering, in the design of carbons and carbon arcs for searchlights, and in precision mechanical devices for gun control provided a wealth of new ideas and information which could be applied to cinema equipment.

Single-unit Design

Leading manufacturers realized that the time had come to abandon the conception of a projection assembly built up from a number of separate units —often designed and manufactured by different companies—and to design a projector as a single unit, thus making it possible to effect many improvements in overall efficiency, since all the factors affecting design could be under the control of one co-ordinating design engineer. Such a composite design permits the introduction of many economies in methods of manufacture, compared with separate units built by different organizations.

The complexity of modern cinema equipment requires that, in addition to the service provided by the manufacturers, the projection room must be under the control of someone who, in addition to being an experienced projectionist, must have some technical knowledge and must be able to understand the design of the equipment he operates. This book is introduced in the hope that it will make more clear some of the less obvious features of design of the BTH S/U/P/A Projector.

THE S/U/P/A PROJECTOR

An outstanding example of single-unit construction is the BTH Single Unit Projection Assembly—S/U/P/A. This equipment, apart from its neat and striking appearance, incorporates a number of novel features designed to overcome the disadvantages of earlier projectors and to contribute to higher standards of performance and overall efficiency.

The frontispiece, Fig. 1, shows the external appearance as viewed from the operating side. There are usually two and sometimes three similar units in a complete installation. They comprise the entire projection room equipment with the exception of the non-synchronous turntable unit, and the only other requisite items are the speakers behind the screen, arc stabilizing resistances, and a rectifier or motor-generator set for the arc supply.

Both projection units are similar in appearance but the apparatus housed in the base differs in the two machines. The projector lanterns are made in two ratings, 50 amp. and 75 amp. Two ratings of sound amplifier are available, 45 watts and 90 watts.

Each projector unit incorporates the following major components :—

- Projector lantern chassis with automatic striking mechanism and thermo-optical carbon feed control.
- Mechanism box; including shutter driving and phasing mechanism, intermittent mechanism, sprocket drives, curved picture gate, driving motor, automatic changeover shutters, wide-aperture lens holder, sound drum driving unit, and sound optical system.
- Fireproof spoolboxes with electrical safety features.
- Illuminated control panel.
- Monitor speaker.
- Fuse panel at rear of Unit.

In the base of one Unit (usually "B" Unit) amplifiers and associated components are located. These are accessible by opening double doors on the non-operating side of the unit ; each assembly is mounted on a separate chassis and connected to the main cable form by plug-and-socket. Each assembly can be drawn forward and, if required, inverted for servicing while still operating in the equipment. Fig. 2 shows the non-operating side of a Projection Unit with all covers removed.

The electrical assemblies in the base of "B" Unit are as follows :—

- Fader Amplifier (main and standby).
- Power Amplifier (main and standby).
- Stabilized power supply unit.
- Contactors for controlling "B" driving motor.
- Speaker field supply units when required.

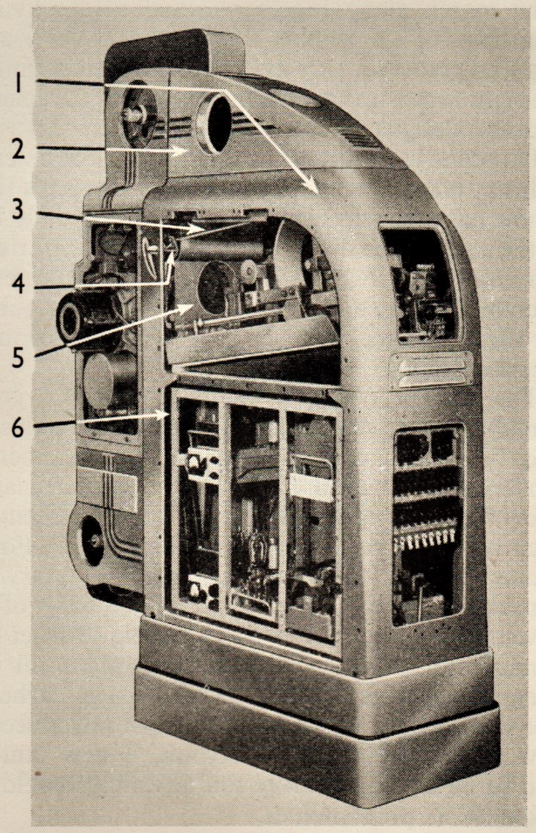
In the base of the "A" unit are mounted :—

- Contactors for controlling both arc lanterns.
- Contactors for controlling "A" driving motor.
- Exciter lamp supply units.

Accessibility for Servicing

Particular attention has been given in the design of the equipment to make all parts easily accessible for service and inspection. The illustration Fig. 3 gives a good impression of this. It shows several of the electrical units withdrawn for inspection ; one of them has the underneath cover removed and is inverted, giving ready access to all components and testing points. The equipment can be fully operational with the units withdrawn as illustrated, because they are still connected to the main system; the plugs on the flexible connections are of a type well proved in the service of naval and airborne radar equipment, and are locked into position when inserted in their sockets.

The mechanism-box cover and the covers of electrical units are secured by quick-acting captive spring-fasteners. The driving motor, sound drum, driving unit, and other mechanical parts are readily accessible for inspection or substitution if necessary.



1. Top Main Frame.
2. Monitor Housing.
3. Mirror-shield operating rod.
4. Rocker-arm assembly.
5. Lower Heat Shield.
6. Control Cubicle and Fuse Panel.

Fig. 2. Constructional Details.

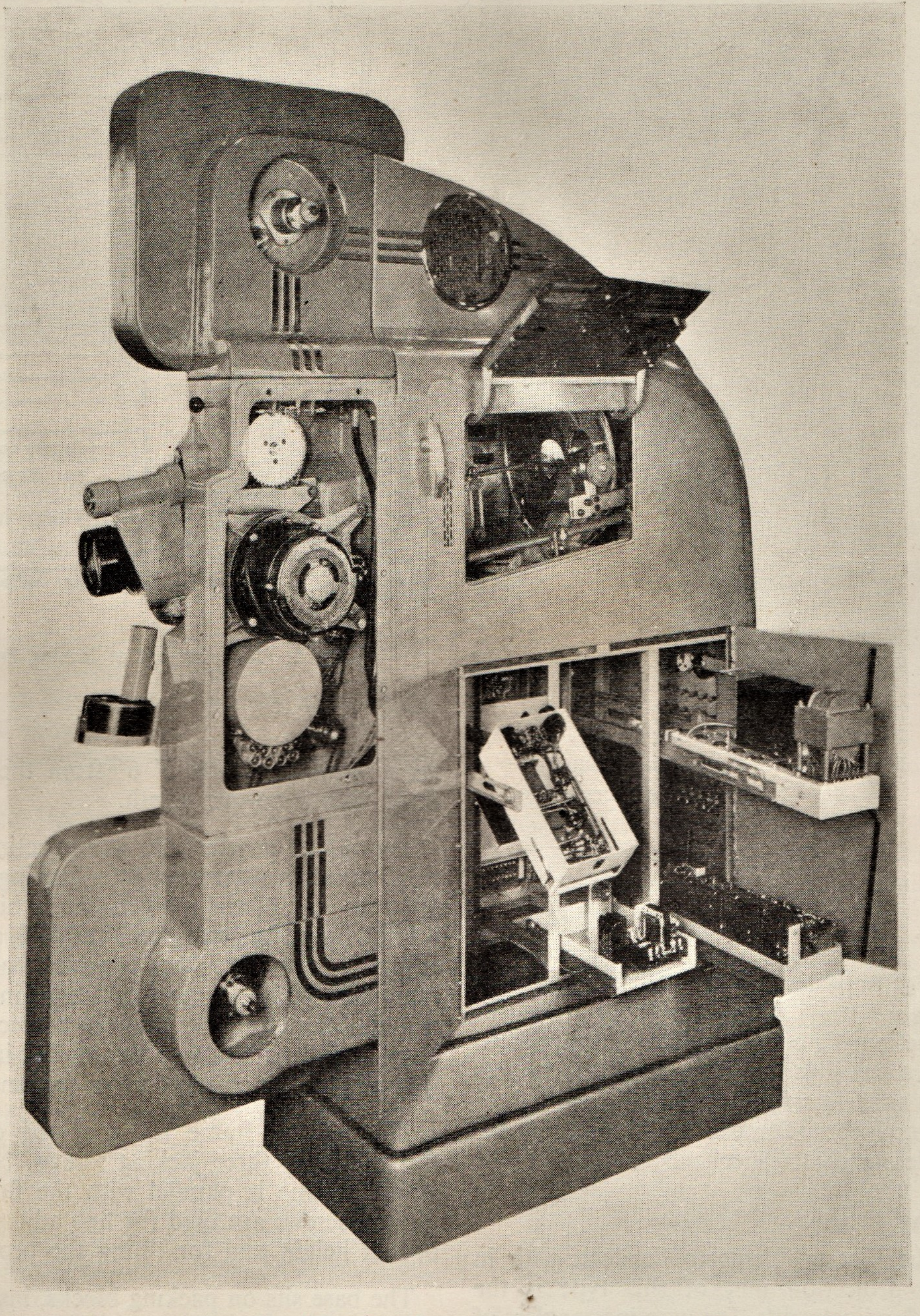
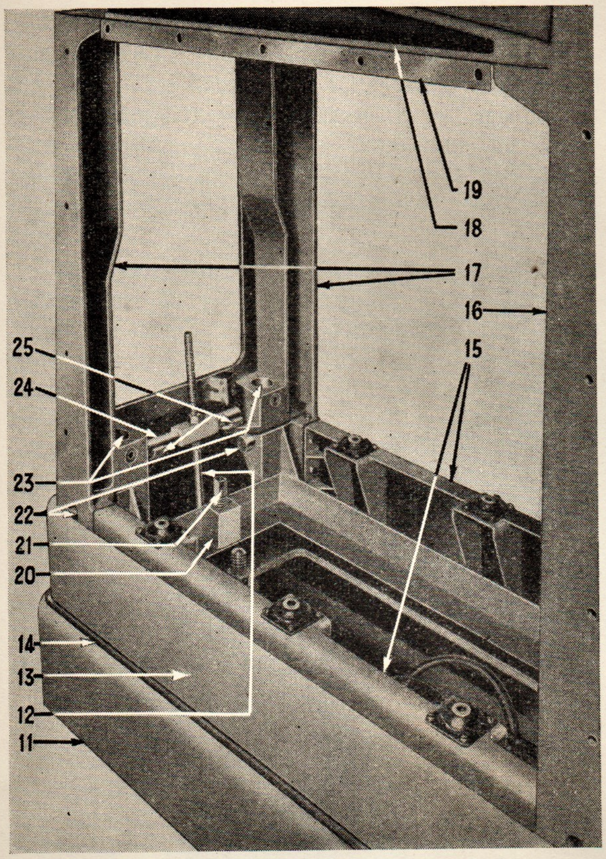


Fig. 3. Non-operating side of S/U/P/A Projector, showing one amplifier tray withdrawn and inverted for servicing.

NOTE: Certain minor changes of design have been introduced since this photograph was taken.

THE S/U/P/A PROJECTOR (cont'd.)



11. Plinth.
12. Anchor Bolt.
13. Base.
14. Rubber Fillet.
15. Frame Distance Pieces.
16. Front Main Frame.
17. Rear Main Frame.
18. Lantern Wedge.
19. Lantern Tray.
20. Jacking Frame.
21. Jacking Screw.
22. Pivot Pins.
23. Angle-adjusting Boss.
24. Anchor Bar.
25. Anchor Bar Cradle.

Fig. 4. Frame Assembly Details.

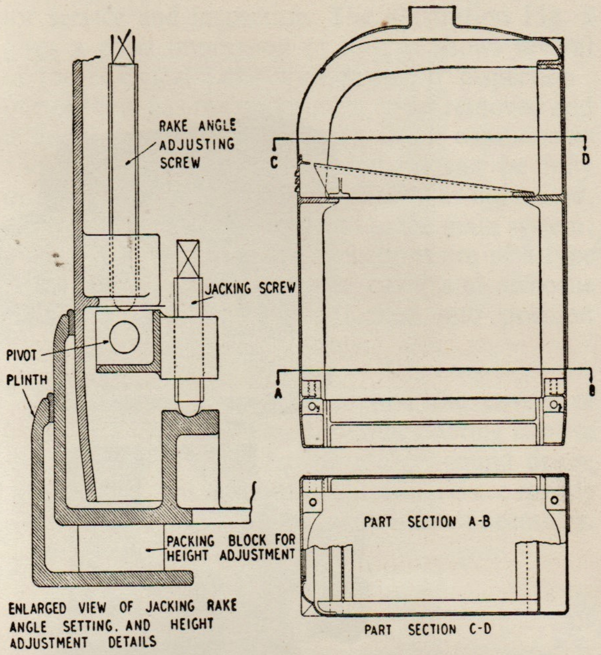


Fig. 5. Arrangement of Jacking Frame.

The projectionist's control panel is arranged to hinge forward and give easy access to back connections. There are two side doors and one rear door to the lantern compartment for access to the carbon holders and feed mechanism.

The Jacking Frame

One of the first problems to be dealt with in designing a projection unit of this type is the provision of adjustments for varying angles of projection and porthole heights while still preserving the unbroken outline and attractive appearance of the unit.

A census was taken of the porthole height and projection angle at 500 representative cinemas in Britain. This showed the average projection angle to be $7\frac{1}{2}°$ down and porthole centre 3′ 6″ from the floor. The projection unit was therefore designed to have a projection angle of $7\frac{1}{2}°$ when the main frame is in an upright position and to be suitable for a porthole centre 3′ 6″ from the floor when fitted with a normal plinth.

To adjust for variations in projection angle, the main frame is supported by a jacking frame ; the front or rear of the main frame is hinged on the jacking frame by pivot pins 22, Fig. 4, and an angle adjusting screw at the opposite end from the pivot pins raises the end of the main frame until the optical centre line is at the correct angle. The angle adjusting screw is not visible in Fig. 4 but is shown in the enlarged cross-section Fig. 5.

The jacking frame is supported on the base 13, Fig. 4 by three jacking screws. Normally the jacking frame is parallel with the floor, and the jacking screws are used for fine adjustment of the optical height and for tilting the projection unit.

The base sits on packing blocks, inside a plinth; a range of plinths of various depths are available, and different-height packing blocks are selected to set the optical centre at approximately the correct height, the final adjustment being carried out by the jacking screws.

The illustrations Figs. 1 and 3 show the main frame vertical, suitable for the average projection angle of $7\frac{1}{2}°$ down. Fig. 58 illustrates a typical projection room and clearly shows the neatness and symmetry of the complete installation.

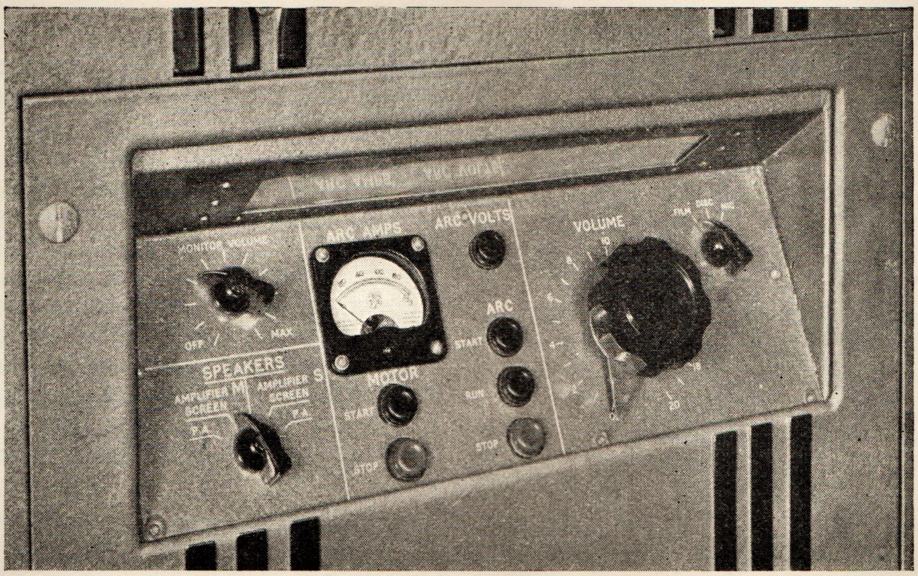


Fig. 6. Control Panel, recessed into operating side of Projector.

The Control Panel

Each projection unit has an illuminated control panel recessed into the operating side of the unit ; the arrangement of the panel is shown in Fig. 6. On each panel are mounted the following controls :—

" STRIKE " push-button for striking the arc lamp at 60% of full-load current.
" RUN " push-button to bring the arc current up to full value.
" STOP " push-button for shutting down the arc lamp.
Ammeter for indicating arc current. A small push-button by the side of the meter, when pressed, causes the meter to indicate arc volts.
"START " push-button for starting the projector motor.
" STOP " push-button to shut down the projector motor.
Volume control knob.
Monitor volume control.
Selector switch for " FILM " or " DISC."

The changeover push-button, for changing over picture and sound from one projector to another, is placed on the top face of the bottom spoolbox at the front, where it is in the most convenient position for the projectionist while he is watching for the changeover cue.

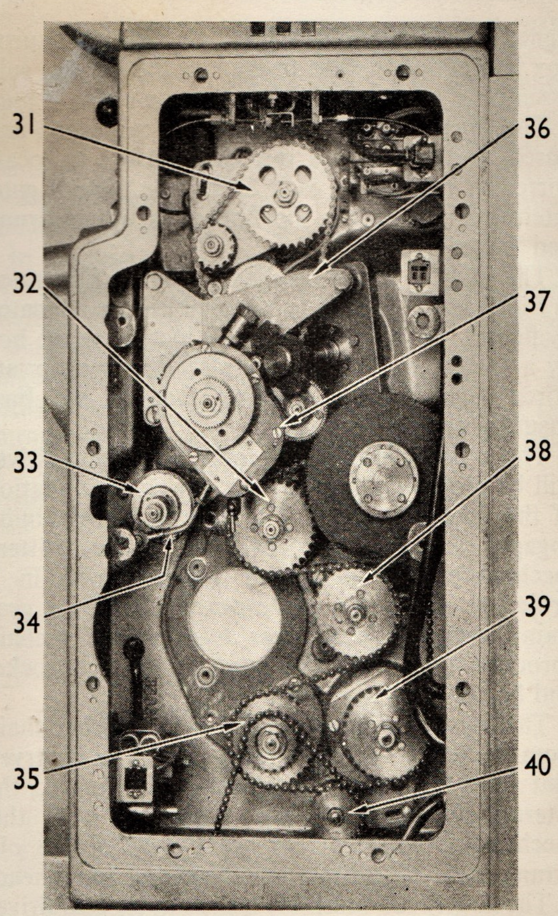
The panel on " B " machine is fitted with the following additional controls :—

Selector Switch for " FILM," " DISC " and " MIC " input.
Selector Switch for " SCREEN " or " P.A." Speakers.
Selector Switch for " MAIN " or " STANDBY " Amplifiers.
Switch and volume control for monitor speakers.

The projectionist has full control of the equipment without having to move from his normal position at the operating side of the projector.

The Mechanism Box

This part of the equipment replaces the mutehead and soundhead of earlier equipments and is de-



31. Top Feed Drive.
32. Sound Feed Drive.
33. Framing Assembly.
34. Framing Link.
35. Bottom Feed Drive.
36. Gear Drive Assembly.
37. Intermittent Mechanism.
38. Idler Assembly.
39. Inching Assembly.
40. Bottom Jockey Assembly.

Fig. 7. Interior of Mechanism Box.

THE S/U/P/A PROJECTOR (cont'd.)

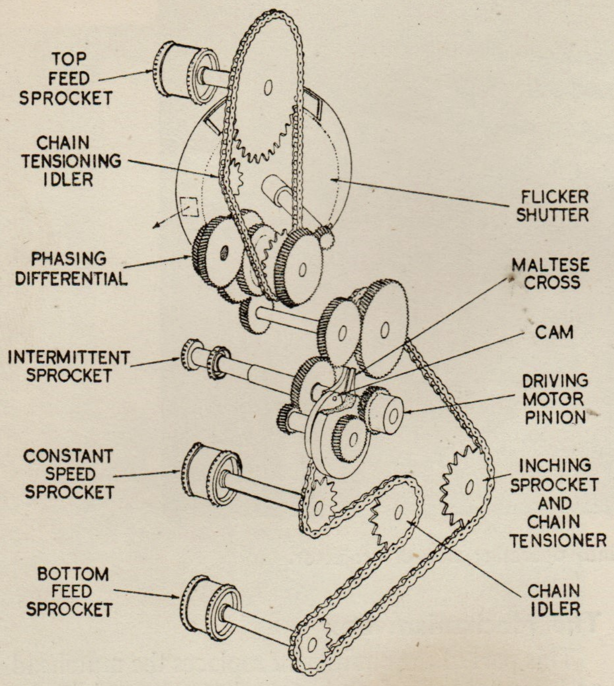


Fig. 8. Arrangement of Driving Chains.

signed on a different basic principle. The mechanism box is primarily a case to enclose the various sub-assemblies, each of which is removable as a unit.

The operating face is accurately machined and bored, and serves as a reference surface to locate correctly, relative to each other, the picture gate, intermittent assembly, film sprockets, sound drum, and flicker shutter.

The interior of the mechanism box is illustrated in Fig. 7 and the major sub-assemblies are indicated by figures. Each sub-assembly is located in the box by a spigot, which fits accurately the appropriate bored hole in the operating face of the box, ensuring correct location.

The arrangement of the gear and chain drives will be more easily understood by an examination of the diagram, Fig. 8. The driving motor pinion engages directly a gearwheel on the intermittent mechanism, the source of greatest load in a projector. From the maltese-cross spindle a gear train drives the shutter gear assembly and a chain sprocket for driving the constant-speed sprocket and bottom feed sprocket.

The top feed sprocket is driven by another chain from the shutter gear assembly. It will be observed that only three film sprockets in addition to the intermittent sprocket are necessary with this mechanism, whereas four were used in the old arrangement of separate mutehead and soundhead.

The largest sub-assembly is the shutter gear drive; it contains a bevel-gear-and-pinion drive to the flicker shutter shaft, a differential gear for compensating framing displacement, and a chain sprocket for driving the top feed sprocket. The differential gear applies framing compensation to the top feed sprocket as well as the flicker shutter, thus helping to maintain the correct-sized film loop at the top of the gate for all positions of the framing handle.

The bearing plate which carries the flicker shutter, all the gearing of the shutter drive assembly, and the intermittent mechanism is spigoted to the mechanism box reference surface, in the same manner as the other sub-assemblies.

Ball-bearings are used throughout ; these are grease-packed and sealed when the mechanism is manufactured. The chains and gears are lubricated with a special gear grease, so that the mechanism box in effect runs dry, a great help in ensuring that the projector is always clean and free from stray oil.

The Intermittent Mechanism

This is designed as a self-contained removable unit, and is an orthodox maltese cross and geneva pin mechanism, contained in an oiltight box so that the cross and pin-roller run in a ventilated oil-bath ; the oil-level is visible through an oil-sight on the side of the box, illuminated so that it is visible through a window in the front of the mechanism case.

From the illustration, Fig. 9, it will be seen that there is a helical pinion mounted on the flywheel and cross-spindle ; this engages with the motor driving pinion. On the other side of the box is a helical pinion and gear ring to drive the shutter gear and projector chain drives, the gear ring rotating on a needle-roller bearing mounted on the intermittent spindle sleeve. The intermittent sprocket is of improved lightweight design and is hardened by a new technique employing very high-frequency electric current ; this makes it possible to produce a sprocket having considerably longer life than was previously obtained.

The Framing Mechanism

Framing is accomplished by rotating the complete intermittent mechanism through a framing

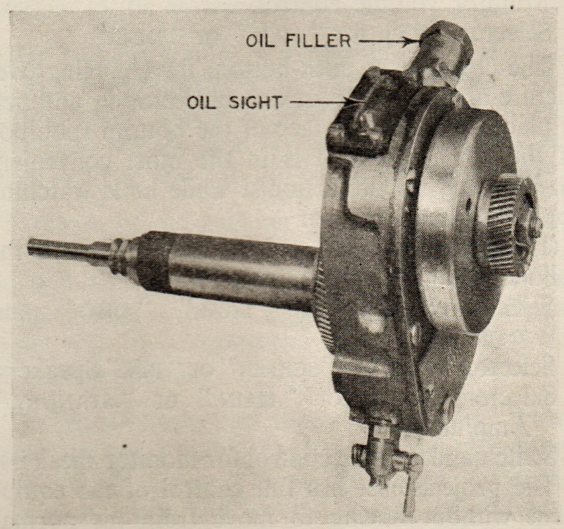


Fig. 9. The Intermittent Mechanism.

link 34 in Fig. 7 coupled to the framing handle assembly ; there is a second link coupling the intermittent assembly to the differential gears on the shutter-gear drive assembly, so that rotating the framing handle rotates the intermittent sprocket, the shutter and top feed sprockets.

The coupling links are resiliently coupled to their anchoring studs ; the framing handle shaft 33, Fig. 7 is supported by a flanged casting. To the end of this shaft is fitted a clutch-boss assembly, consisting of an inner clutch and compression spring to ensure positive operation of the framing handle and to prevent any possibility of creep.

The Drive Motor Assembly

The driving motor is a 240 volt, 1440-r.p.m. capacitor motor resiliently mounted on a bracket which carries the pinion engaging with the intermittent driving gear ; the motor shaft is flexibly coupled to the shaft of this pinion. This bracket is very accurately located on the motor support plate, since it is important that the pinion and intermittent gear should be correctly meshed at all framing positions of the intermittent mechanism.

In the illustration Fig. 7 the motor support plate has been removed, but in Fig. 3 the motor and support plate are shown in position.

The Inching Assembly

An inching handle is provided on the operating side of the machine below the sound optical system. Its main purpose is to rotate the mechanism by hand, to make sure the film-threading is correct. The shaft is eccentrically mounted in a two-bearing housing, and, with a chain sprocket, provides tension-adjustment for the sound feed and bottom sprocket drive chain.

Bearing-housing Assemblies

The three film sprocket bearing-housing assemblies are all similar in design. They are located and fixed to the reference surface of the mechanism box by a spigot and socket, the flange of the bearing housing being secured by three fixing bolts, permitting easy replacement of any one assembly, and ensuring that the replaced assembly is properly located to place the film sprocket in true alignment with the film path.

The Flicker Shutter

Before describing the special features of the S/U/P/A flicker shutter, it would be well to consider what is required of the ideal flicker shutter.

The instant the intermittent sprocket commences to move, the flicker shutter should completely cut off the light until the intermittent sprocket has completed its movement, and, the instant the sprocket is stationary, the shutter should allow the full quantity of light to be projected. Also, for the purposes of reducing the effect of flicker, the light must again be obscured for a similar period, midway between the intermittent sprocket stopping and restarting.

The ideal flicker shutter can, therefore, be represented by a light-time diagram as shown in Fig. 10 (a). It is not practicable to obtain an effect as shown in this diagram, however, because it takes a finite time to cut off the light and to restore it. The efficiency of a flicker shutter is determined by the length of time it takes the shutter to cut off and to restore the light ; this may be measured in fractions of seconds, or, as the flicker shutter rotates at a constant speed of 1440 r.p.m. it may be measured in degrees of shutter rotation.

In the case of a conventional rear shutter of the type shown in Fig. 11 (a), the time taken to cut off the light is 52° of shutter rotation, which produces a diagram similar to Fig. 10 (b). Comparing this diagram with the theoretical diagram, it will be noticed that the shaded area which represents the amount of light projected is much less in the case of Fig. 10 (b) than 10 (a).

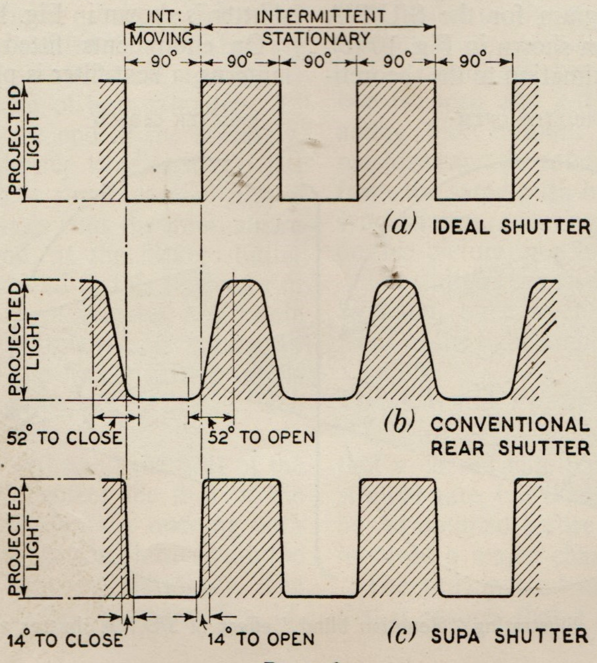


Fig. 10. Flicker-shutter light-time Diagrams.

THE S/U/P/A PROJECTOR (cont'd.)

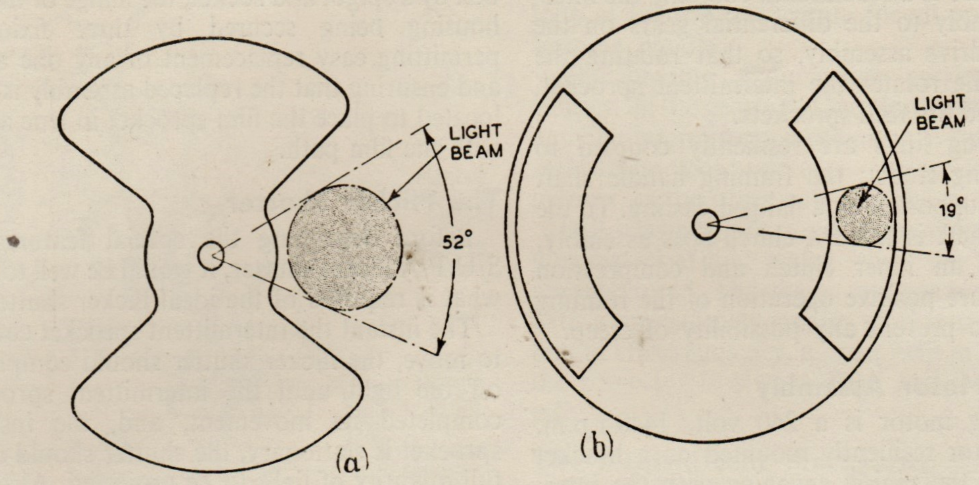


Fig. 11. Comparison between **(a)** a conventional rear shutter and **(b)** the S/U/P/A dished shutter.

In order more nearly to approach the theoretical diagram, the S/U/P/A flicker shutter is designed to cut the light beam where its diameter is the smallest, immediately behind the gate aperture. By adopting a " dish " form of shutter rotating on an axis at an angle to the light beam axis, it has been possible to use a large-diameter shutter without increasing the overall width of the mechanism box. Fig. 11 shows a comparison between a conventional rear shutter and the S/U/P/A " dish " shutter.

The diagram Fig. 11 (b) shows the developed S/U/P/A shutter, whereby the light is cut off in 19° of rotation. A further reduction to 14° is obtained by the use of a venetian blind effect shown diagrammatically in Fig. 12. From this diagram, it will be seen, that, at the commencement of light cut-off, the thin edge of the vane has practically no effect in obscuring the light, but, as the shutter rotates, the blade presents its broader face to the light beam and in effect cuts off the light completely 5° earlier than if the blade were absent. The light-time diagram for the S/U/P/A flicker shutter is of the form shown in Fig. 10 (c), which is a very close approximation to the theoretical ideal diagram. This improved shutter efficiency is one of the valuable features which contribute to the high light output obtainable from the equipment.

A limited amount of adjustment is provided in the relative position of the flicker shutter and its driving spindle to remove top or bottom " ghost." The intermittent mechanism must first be correctly meshed with the flicker-shutter gearing, and a final adjustment can be made by slackening the screws, in the curved slots near the centre of the flicker shutter ; this permits rotation of the shutter on its hub. Top " ghost " is caused by a lagging shutter, so to correct for this the shutter must be rotated clockwise, the reverse being the procedure for bottom " ghost."

If an even top and bottom " ghost " is present, it can be corrected by an adjustment of the aperture vanes, but care must be taken in doing this to avoid loss of light.

The appearance of the " dish " form of flicker shutter is shown in Fig. 13.

On equipments fitted with 75-amp. projector lanterns, a heat filter is placed in the flicker shutter

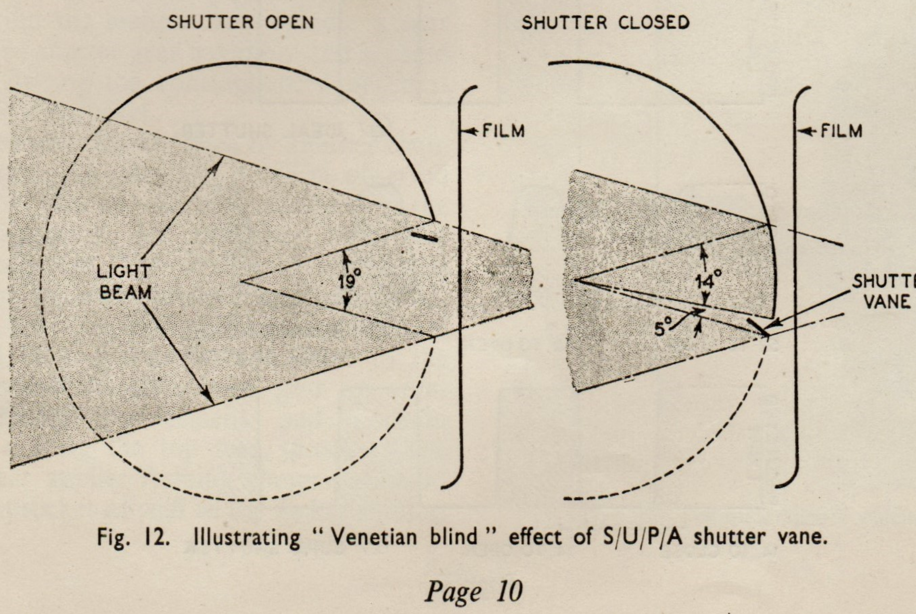


Fig. 12. Illustrating " Venetian blind " effect of S/U/P/A shutter vane.

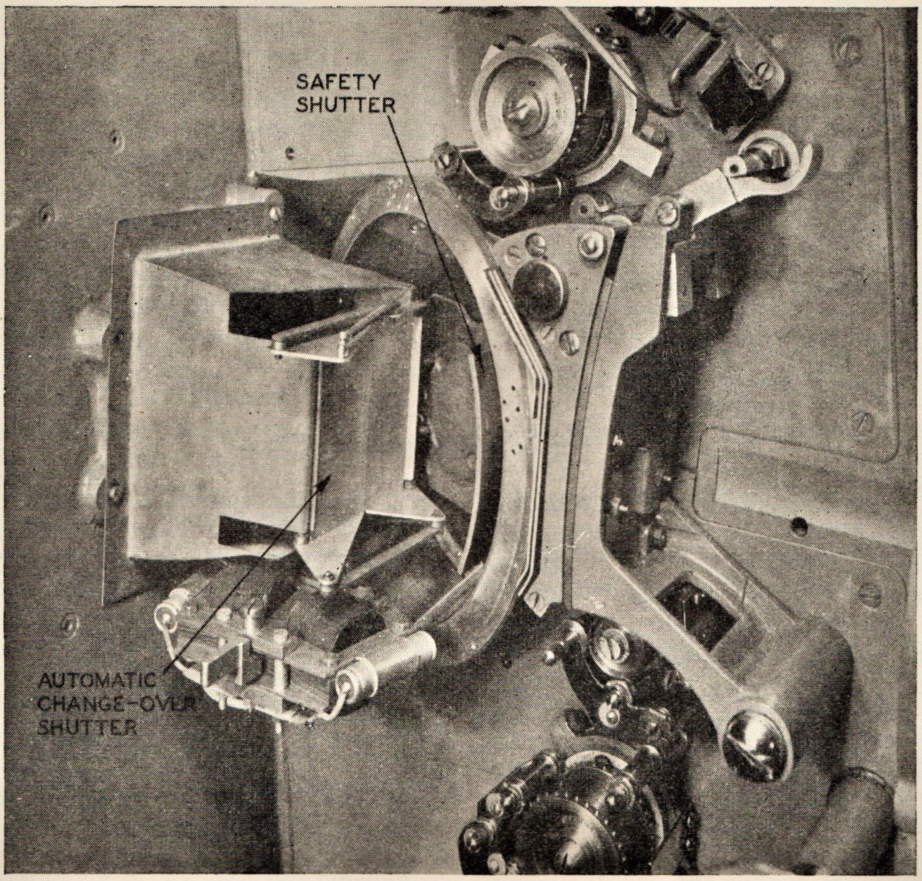


Fig. 13. Arrangement of Shutter and Gate, showing Safety Shutter and Automatic Changeover Shutter.

aperture to prevent overheating and buckling of the film. As the heat filter is only in the light beam during the period when the light is being projected on to the screen, and is cooled by air turbulence as the shutter rotates, it cannot become overheated.

The Safety Shutter

The safety shutter is made of a heat-resisting aluminium alloy ; it is operated magnetically, and is located inside the flicker shutter dish. The safety-shutter assembly is carried by a ball-bearing on the end of the flicker shutter shaft, and is free to rotate through an angle of approximately 70° between fixed stops. On the end of the assembly, opposite to the safety shutter vane, are two flat permanent magnets with a small parallel airgap between them. In this airgap runs the internal rim of the flicker shutter, and, as the flicker shutter rotates, eddy currents induced in this internal rim exert a drag on the permanent magnets, and rotate the safety shutter until it opens and comes up against a limit stop. As the flicker shutter slows down, the safety shutter is closed by gravity, due to the weight of the magnets.

The safety shutter will withstand the heat of the arc indefinitely, and will protect the film in the event of a projectionist accidentally opening both the lantern dowser and changeover shutter with the lantern running and the machine stationary. The safety shutter can be seen in the illustration Fig. 13.

Automatic Light Changeover

Automatic light changeover from one projector to the other is accomplished by an electrically-operated shutter assembly mounted inside the flicker shutter dish, and under the light tunnel cover ; it is placed in such a position that it intercepts the light beam before it reaches the safety shutter.

The changeover shutter is in two sections like two blades or doors, made of heat-resisting aluminium alloy and hinged on a vertical axis.

The blades are electrically-operated by two coils, one to open and one to close, through a quick-acting link motion. The shutters on the two machines and the sound changeover are all operated from the same push-button, so they are always in synchronism, ensuring that there is never either a double picture or a blank screen.

The shutters can also in an emergency be operated by hand, by a lever which projects through the front of the light tunnel.

The Curved Picture Gate

Cinema engineers have realized for many years that a curved gate has many advantages over the straight gate, but there were practical difficulties to be surmounted before it could be introduced, as it involved a major change in projector layout.

The principal advantage of the curved gate is that it ensures that a film initially flat will lie flat

THE S/U/P/A PROJECTOR (cont'd.)

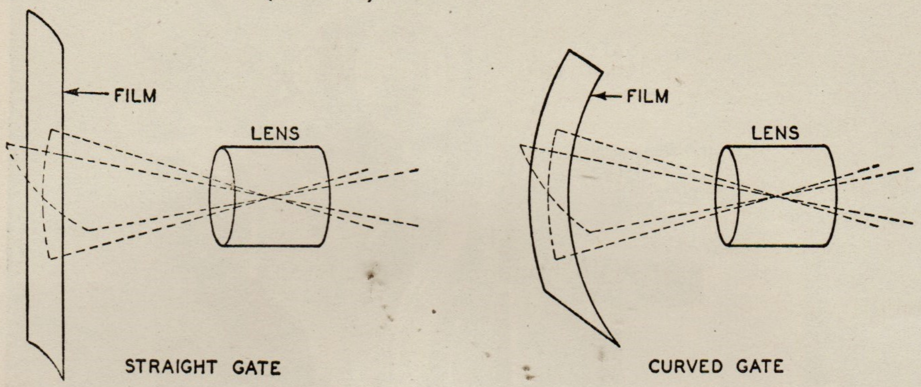


Fig. 14. Effect of Straight and Curved Gates.

in the gate at the aperture, with a minimum amount of skid pressure. This results in more even focus and better picture projection over the whole area of the picture ; there is also less wear and tear on the film, less load on the intermittent mechanism, and less wear on the intermittent sprockets.

If we consider a short length of flat film held between two rollers or sprockets, or even between two spools on the rewinder, a very light pressure applied to the edges of the film will cause it to bow or buckle. If the length of film, instead of being held straight, is bent in a curve which may be of quite large radius, it will be found that it is necessary to apply a very much greater pressure to the edges of the film before it can be made to bow or buckle. In fact, a short length of the film has to change from a curved to a straight path before it can be made to bow at all.

Now, in the straight gate, pressure must be applied to the face of the film at the edges, to ensure that it will lie flat in the gate at the aperture. With a curved gate, however, pressure for this purpose is unnecessary, because the very fact that the film is pulled taut against a curved surface ensures that it must lie flat at the aperture. A certain amount of skid pressure is necessary in either type of gate, to assist in arresting the motion of the film the instant the intermittent sprocket becomes stationary.

Another advantage of the curved gate, which is shown in Fig. 14, is that it can be designed to ensure that the film lies in the true focal plane of the lens. The true focal area of a projection lens is not a flat plane but is a curved surface on which all points are at the same distance from the focal point of the lens. The radius of the curved gate can be designed to satisfy this condition, and can thereby further contribute to ensuring an even focus over the whole of the picture area.

Yet another feature of the S/U/P/A curved gate which will appeal to projectionists is its unique accessibility. Fig. 13 shows the gate closed, and Fig. 15 shows it fully open with the lens holder in the raised position. With the gate in this latter position, all parts can be cleaned and inspected quickly and safely. The hinged portion carries the aperture plate, and the contact surfaces are faced with hardened steel skids ; light balanced springs which bear on the sides of the film are mounted in the fixed portion of the gate, these springs being adjustable while the projector is running. It is unnecessary to open the gate fully as shown in Fig. 15 for lacing film. An intermediate stop is provided which permits the gate to open sufficiently for lacing without having to raise the lens holder.

The gate is cooled by a system of heat reflector plates with an air space between them ; this system is so effective that at the end of a day's run even with a 75-amp. arc lantern it is possible to place the hand on any part of the gate without discomfort.

There is a framing aperture at the top of the gate

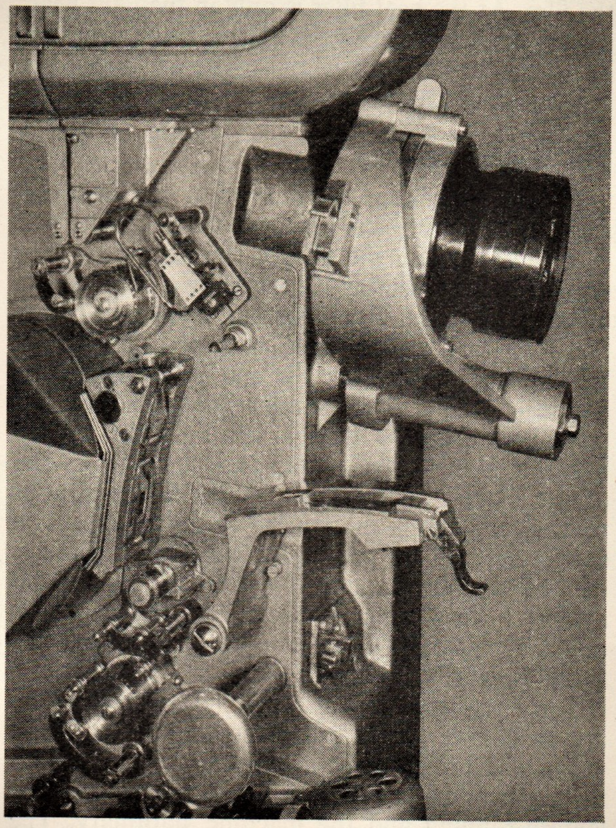


Fig. 15. Curved gate open and Lens holder raised.

with a miniature lamp behind it to assist in checking the lacing.

To prevent the possibility of a film weaving during operation, there are two " Ardoloy " guide pads in contact with the edge of the film, one immediately above the aperture and one level with it, so that the film is guided at the point where it is required to be steady, instead of by spring-loaded guide rollers at the top or bottom of the gate some distance from the aperture. One pad is preset and the other spring-loaded so that it exerts a constant light pressure on the edge of the film.

Lens Holder

In conjunction with the development of S/U/P/A, Messrs Taylor, Taylor, and Hobson Ltd. developed a range of projection lenses with an aperture value of f 1·9. These lenses are larger in diameter and heavier than previous standard lenses, and the S/U/P/A lens holder is specially designed to carry them. The substantial ball-bearing hinge contains a coil spring which counter-balances the weight of the lens and holder, so there is no danger of the lens or projector being damaged or thrown out of alignment by the lens being accidentally dropped back ; actually a light pressure is required to press the lens holder home into its locked projecting position.

As lenses of such a wide aperture are bound to be more critical to focus, a coarse and fine finger-touch focus adjustment is provided on the lens holder.

Sound Drum Unit

The sound drum, complete with its electrical driving elements, flywheel, shaft, and bearings, is an entirely independent and easily-replaceable unit.

The driving elements consist of a special form of the " Ferraris " induction-disc motor. A thin carefully-balanced disc of low-resistance material rotates in the airgap of three sets of electro-magnets. Eddy currents induced in the metal disc produce a driving torque which rotates the disc. In addition to producing this driving torque, the disc also provides a damping torque which prevents oscillations occurring in the rotating system. Some of the electromagnets have a small direct current injected in their windings which induces the damping torque ; variations in this direct current also provide a fine-speed control of the drum motor.

This form of driving unit has a very desirable characteristic in that the speed remains constant over small variations in supply voltage and frequency, providing a very stable drive for the drum.

The drum speed is set on installation to suit local conditions and to give an equal loop above and below the upper and lower drum rollers. The lower drum roller is friction-driven from the inner edge of the drum, and when running keeps the film taut against the drum surface.

Fig. 16 shows a cross-section of the sound drum unit, and the bearing arrangement. The bearings nearest the drum are of a special high-precision type and are packed with Crimsangere No. 8 grease ; a lubricating pipe is provided so that a few drops of Asteroil " AA " can be added should the grease show signs of losing its oil content with age.

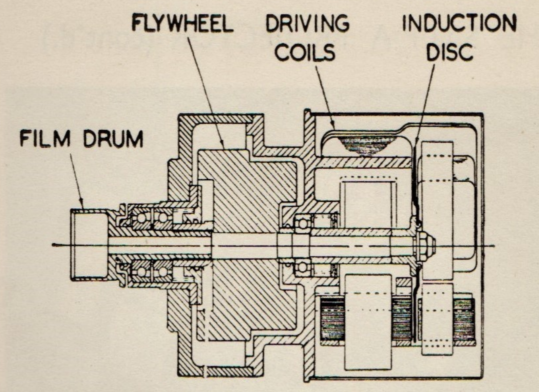


Fig. 16. Cross-section of Sound Drum Unit.

Sound Optical System

The purpose of the sound optical system is to produce a variation in the quantity of light falling on the cathode of a photoelectric cell in accordance with variations in the density or contour of the film sound-track image. A relatively-simple and frequently-used method of doing this is to scan the sound track with a narrow slit of light, and the light passing through the film is projected on to the P.E. cell cathode.

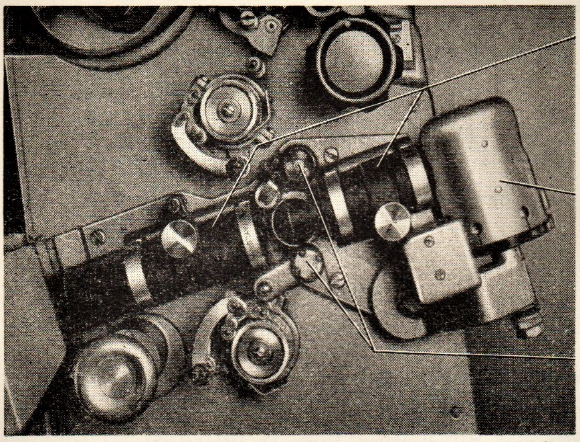
It will be apparent, however, that the width of the scanning slit must be comparable with the dimension of the smallest image it is required to reproduce. Assuming that it is desired to reproduce frequencies up to 10,000 cycles, the width of one complete cycle of a 10,000 cycle note on variable area recording is 0·0018″ ; so that, to avoid a serious loss in output at this frequency compared with lower frequencies, the slit width must not be greater than 0·0009″, preferably less ; the theoretical scanning slit would be approximately 0·010″ long × 0·0005″ wide. This is a very small area and restricts the maximum amount of light that can reach the P.E.C. and therefore the output from it.

Also, the position of the film relative to the optical system is very critical ; an error of 0·001″ in the focus will cause a serious loss of the higher frequencies. The slit must be evenly illuminated at the same light-colour over its whole area, otherwise distortion and lack of fidelity is introduced in the reproduction.

An improved design of optical system is used in the S/U/P/A equipment which avoids many of the disadvantages of earlier designs.

The exciter lamp is of the Mazda prefocused type in which the filament dimensions and shape are carefully controlled ; in the final stages of manufacture the filament is correctly positioned relative to a standard lampholder. A locating ring is soldered on to the lamp cap so that the filament of

THE S/U/P/A PROJECTOR (cont'd.)



41. Sound Optical System.
42. Exciter Lamp Housing.
43. Sound Drum Rollers.

Fig. 17. Sound Optical Assembly.

any lamp will always take up the correct position when fitted into the lampholder of the optical system. This ensures even light-intensity of the whole illuminated area of the sound track.

Discolouration and short life of exciter lamps is mostly due to frequent switching on and switching off, or, alternatively to running at full current for long periods. In the S/U/P/A equipment this is avoided by arranging that the exciter lamp is run at full current only while film is being projected. When the projector motor is switched off the exciter lamp current is considerably reduced, and is only switched off completely when the whole equipment is shut down.

The arrangement of the optical system is shown in the illustration Fig. 17. It is in two sections, one placed between the exciter lamp and film, the other between the film and photocell. A condenser lens system in front of the exciter lamp projects light from the filament on to the film sound track in the form of an evenly-illuminated rectangle. This light passing through the film produces an image of the sound track on a lens in the second part of the optical system ; the lens magnifies the image approximately six times and projects it on to a scanning slit which can be as much as 0·003″ thick without causing any serious loss of output at 10,000 cycles. The light passing through the scanning slit is projected on to the cathode of a photoelectric cell. The illuminated area of the sound track is much larger than if a scanning slit of small dimensions were focused on to the sound track ; this makes it possible to locate the slit in a more convenient position in the optical system.

An advantage of this arrangement is that, as there is no slit of light on the film, the scattering and dispersion of light at the film is reduced. The optical system is so designed that changes in methods of recording do not affect the high quality of reproduction. The light falling on the photocell is a circle varying evenly in light intensity whatever recording is used, and this compensates for variations in sensitivity over the surface of the cell cathode.

Fireproof Spoolboxes

The fireproof spoolboxes introduced by BTH in 1938 are incorporated in the S/U/P/A equipment. Each spoolbox has an inner circular shell which contains the loaded film spool. It has been proved by demonstration that one of these boxes containing a spool of film can be placed in the centre of a heap of 2000 ft. of old film, the heap can be set on fire, and when the fire has burnt out and the spoolbox is opened, the film inside will be found to be quite undamaged.

Each fire trap is fitted with a spring-loaded guillotine, and if a fire occurs in the projector gate a fuse releases the guillotines which cut the film and seal the fire traps ; at the same time the arc lamp and projector motor are automatically shut down. Another feature incorporated is a top spoolbox door interlock ; if the door is opened while the projector is running the arc lamp and motor are shut down.

The top spoolboxes are provided with mica windows so that a lamp placed at the back of the box on the outside gives adequate illumination for the projectionist to see how much film is on the spool.

The spool-hubs run on ball-bearings and are of a larger diameter than previous designs to ensure that the spools run truly in the spoolbox and the flanges do not foul the film as they rotate ; the hubs are fitted with ejectors so that by pressing two levers together the spool is pushed partly off the hub.

Film Threading

Fig. 18 shows the correct threading of the film in the projector ; it also indicates the pad roller and firetrap roller clearances.

THE PROJECTOR LANTERN

General Principles

The projection of cinematograph films demands a light source that will satisfy the following rather stringent conditions :—

(a) High intrinsic brilliance.
(b) Stability as regards colour and intensity.
(c) A colour approximating to daylight.
(d) Fairly even illumination over the whole screen area.

The D.C. carbon arc is the only light source at present available which will meet these conditions and produce a large total light output.

The original D.C. carbon arc lamp obtained its light from the incandescent walls of the positive carbon-crater. Projector lanterns using this light source were employed successfully for many years, for they can be made stable in operation and the carbon burning-rate is low, so that they can easily

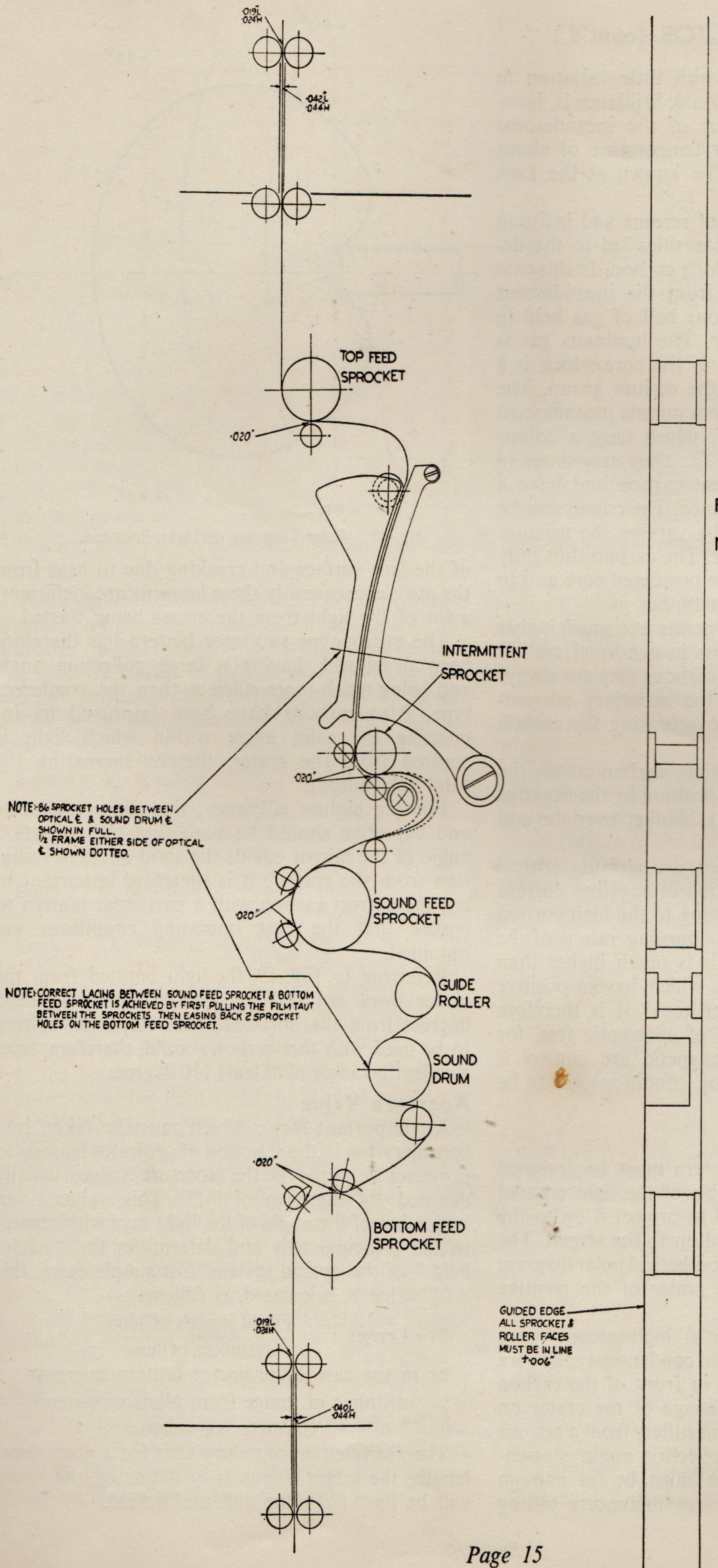


Fig. 18. Film-threading Diagram.

NOTE : Later models are fitted with a new type of intermittent guide pin assembly. These should be threaded with 80 sprocket-holes between the optical and sound drum centre lines.

THE S/U/P/A PROJECTOR (cont'd.)

be kept in trim by hand with little variation in screen illumination. The intrinsic brilliance is, however, limited by the colour of the incandescent carbon which has a colour temperature of about 3220°C. and has come to be known as the Low Intensity Carbon Arc.

The increase in the size of screens and insistent demands for higher light intensities led to the development of the High Intensity carbon. In this case the light is not obtained from the incandescent carbon, but from a luminous ball of gas held in place by the carbon crater. The luminous gas is produced by volatilization of the core which is a mixture of rare earths of the cerium group. The light is actually obtained from minute incandescent particles in the ball of gas, which have a colour temperature of about 6000°C ; they are whiter in colour than the incandescent carbon and have a much higher intrinsic brilliance. The colour can be controlled to some extent by varying the mixture with which the core is made. The carbon thus only acts as a shell to contain the powdered core and to form a crater to hold the luminous gas.

High Intensity Carbons operate at a much higher current density than carbons in a normal carbon arc, so except for very large carbons they are always copper-coated to provide the necessary current-carrying capacity without overheating the carbon shell.

Besides the boundaries of the carbon crater, the luminous gas is also held in position by the negative carbon flame which forms a blanket over the end of the positive carbon.

The High Intensity carbon arc is fairly critical as regards arc length, position of negative, current density, and ventilation. Owing to the high current density, the positive carbon burning rate is of the order of 12″ per hour ; this is much higher than with low intensity carbons, which have a positive burning rate of about 2″ per hour. It is therefore essential to use some form of automatic feed for the carbons and electro-magnetic arc control if continuously-stable operating conditions are to be obtained.

Light-collection Angle

An efficient projector lantern must be designed to collect as much as possible of the light emitted from the carbon crater and to project it on to the film in the gate aperture and on to the screen. The diagram, Fig. 19, shows a hypothetical polar diagram of light emission from the crater of the positive carbon.

Early examples of powerful high-intensity projector lanterns, known as the condenser type, were arranged with a lens system in front of the carbon crater which projected an image of the crater on the gate aperture. This system suffers from a serious disadvantage, in that the collection angle is essentially small since the crater must be far enough away from the lens to prevent premature pitting

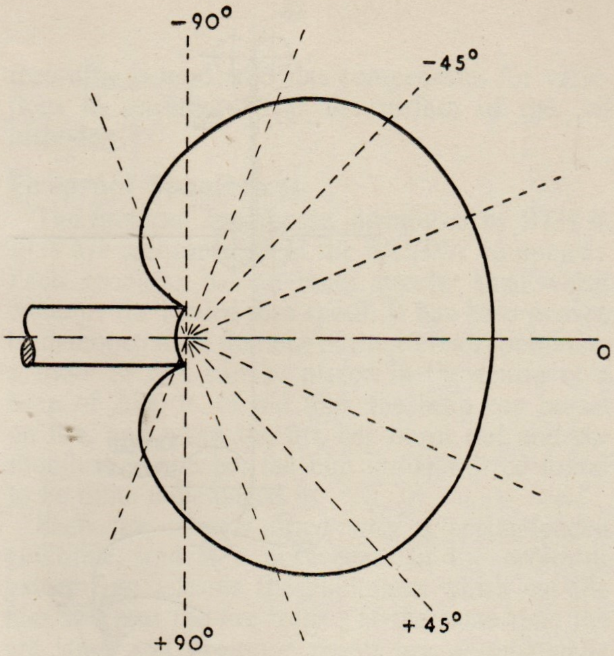


Fig. 19. Polar Diagram of Light Emission.

of the lens surface and cracking due to heat from the arc ; consequently these lanterns are inefficient, a lot of the light from the crater being wasted.

The mirror-type projector lantern has therefore been developed, having a large collecting angle and being much more efficient than the condenser type. Also carbons have been improved by increasing the solid angle within which light is emitted from the crater, thereby increasing the total light output.

For the highest efficiency, the mirror diameter and curvative should be such that the collection angle of the mirror equals the solid angle of radiation from the crater ; it is therefore important to use the correct carbon with a particular lantern to ensure that the best operating conditions are obtained.

Referring to Fig. 19, the light emitted from the crater does not fall off rapidly until about 55 degrees from the horizontal; an ellipsoidal mirror to be used with this carbon should, therefore, have a collection angle of at least 110 degrees.

Aperture Value

An important factor which must be taken into consideration in the selection of projector lenses and projector lanterns is the aperture value, usually denoted by the symbol "f." This value is an indication of the angle of the light rays with respect to the principal axis and determines the "useful field" of the optical system. For simple cases, this "f" value is calculated as follows :—

$$\text{For Lenses, } f = \frac{\text{Focal length of lens}}{\text{diameter of lens}}$$

or in the case of projector lantern mirrors

$$f = \frac{\text{distance of image from plane of mirror}}{\text{diameter of mirror}}$$

The above equations show that for a given focal length, the larger a lens is in diameter, the lower will be its "f" value and useful field.

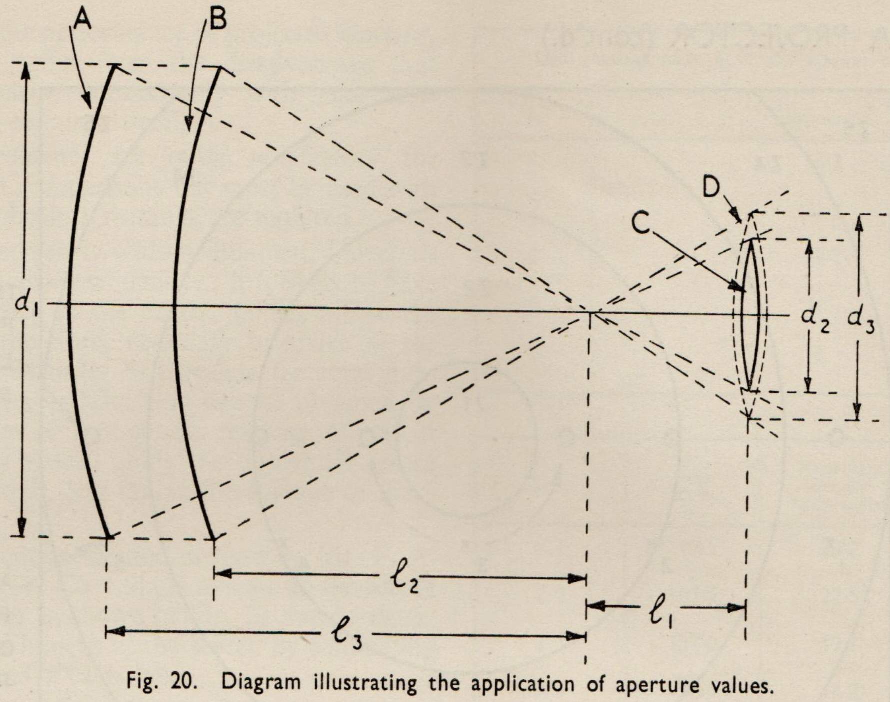


Fig. 20. Diagram illustrating the application of aperture values.

The significance of the lantern aperture value is apparent when it is considered in relation to the projector optical system with which it is to be used. Fig. 20 is a diagram of two lantern optical systems and two projection lenses ; the various " aperture values " for these lanterns and lenses are as follows :—

Lantern A, f value $= \frac{l_3}{d_1}$

Lantern B, f value $= \frac{l_2}{d_1}$, less than $\frac{l_3}{d_1}$

Lens C, f value $= \frac{l_1}{d_2} = \frac{l_3}{d_1}$

Lens D, f value $= \frac{l_1}{d_3} = \frac{l_2}{d_1}$

It is apparent from Fig. 20 that if lantern A is used with lens C or D, the total light from the lantern will be collected by the lens.

If the lantern B were used with lens C a large proportion of the light from the lantern would not be collected by the lens and the full benefit of the lantern would not be realized.

This is a condition likely to be met in practice. The lens is often the limiting feature since lenses of large aperture (small f value) are expensive and the trend of lantern design is to reduce the f value as a consequence of increasing the collecting angle. The correct matching of lantern and projector lens is a very important factor in obtaining the highest efficiency from the combination.

Light Measurement

The unit of luminous intensity is the candle-power. It has been established internationally as the luminous intensity of a specified light source known as the International Candle.

It should be clearly understood that candle-power is not a measure of quantity of light. Nor is the candle-power of a source affected in any way by the distance between the source and any surface it may be illuminating. Candle-power is a measure purely and simply of the potentialities of a light source.

Referring to the diagram in Fig. 21, imagine a light source of one candle-power placed in the centre of a sphere 1 ft. radius, then the whole of the inside surface of the sphere will be illuminated at a density of one " foot-candle " and each square foot area of this sphere receives a " luminous flux," or quantity of light, of one " lumen." As the sphere

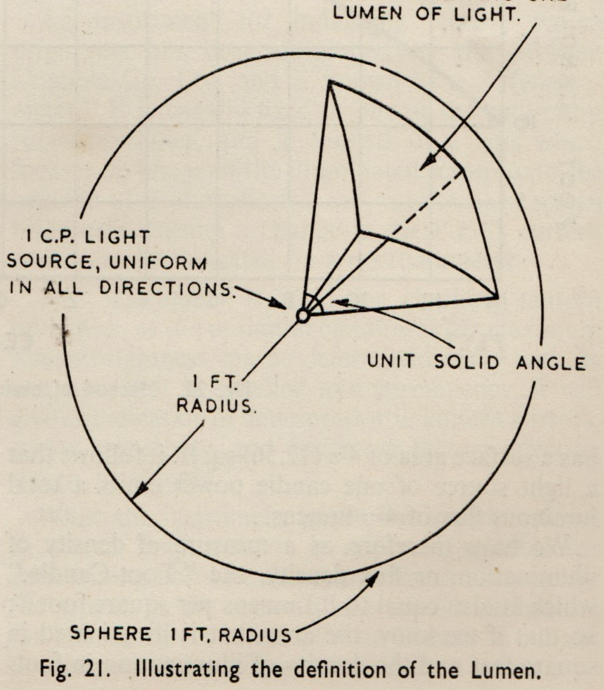


Fig. 21. Illustrating the definition of the Lumen.

THE S/U/P/A PROJECTOR (cont'd.)

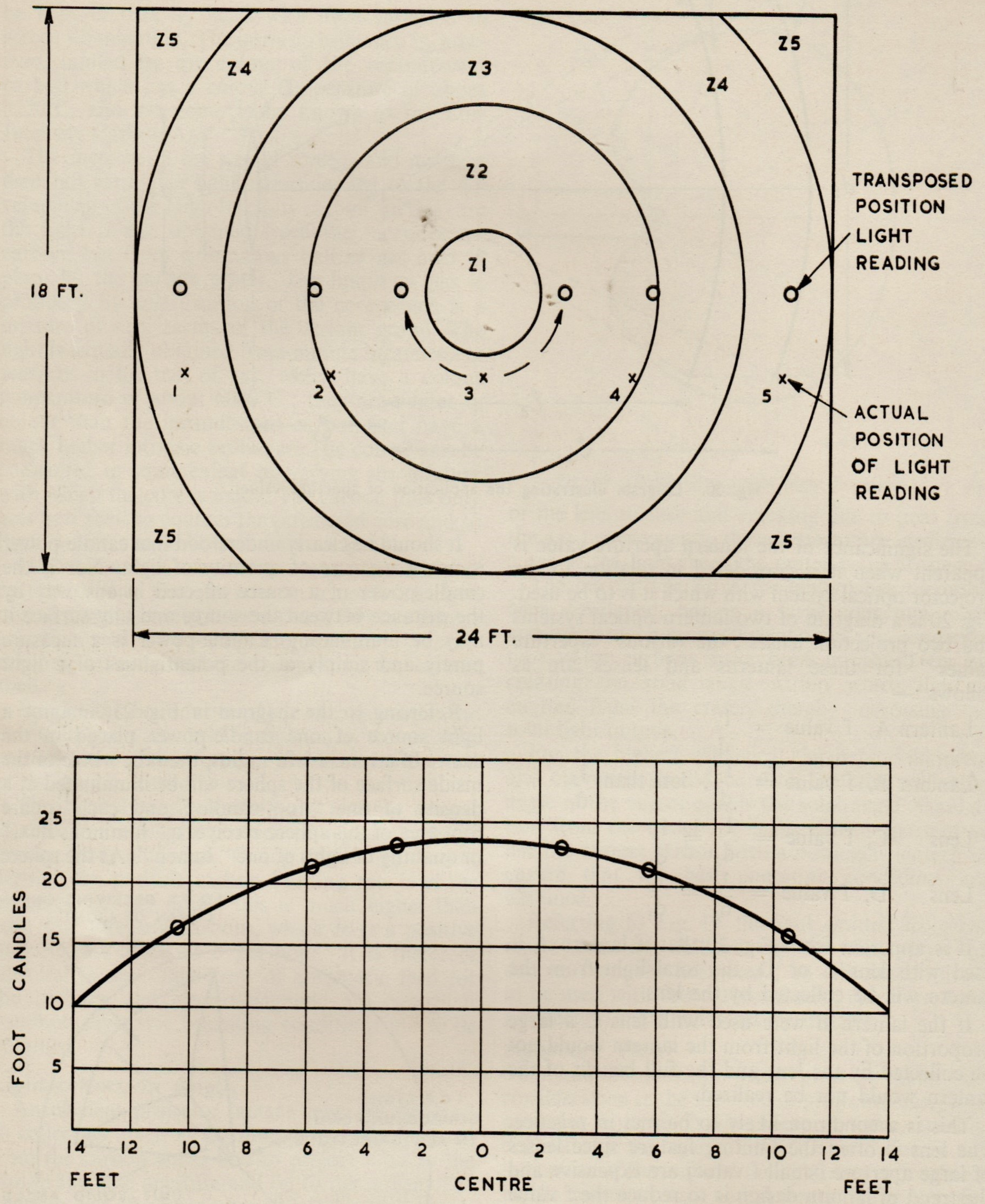


Fig. 22. Method of evaluating screen illumination.

has a surface area of 4 π (12.56) sq. ft. it follows that a light source of one candle power emits a total luminous flux of 4 π lumens.

We have therefore, as a measure of density of illumination, or flux density, the " Foot-Candle," which is also equal to " Lumens per square foot "; so that if we know the area that is illuminated in square feet and the density of illumination in foot-candles, the product is total lumens or total light flux, a quantity in which we are usually interested. A measure of illumination density alone, (foot-candles) does not give complete information as to the performance of a projector lantern or other light source.

There are several different forms of light meters which are calibrated in foot-candles, and suitable for checking the performance of projector lanterns, but they all suffer from the disadvantage that calibration varies considerably with age, temperature, and colour of the light.

Such instruments are quite satisfactory for making direct comparisons but must be used with discretion if absolute readings are required.

A cinema screen is seldom illuminated over its whole area at an equal density ; it is likely to have a higher density in the centre, falling off at the edges. It is therefore, necessary to arrive at the mean density in order to calculate the total flux. A very rough approximation can be obtained by taking a series of foot-candle readings at, say, 5 points equally spaced along the horizontal centre line of the screen, and taking the average of the 5 readings.

A more accurate method devised by Mr. F. A. Tuck of the BTH Co. Ltd., is to split up the screen area into zones as shown in Fig. 22 and to determine the total lumens at the screen by summating the total lumens of each zone.

A set of, say, five light readings are taken at appropriate intervals across the screen at a convenient height, and the position at which the readings are taken is then transposed to the equivalent position on the horizontal centre-line as shown in Fig. 22. From this information a curve is drawn representing the distribution of light density across the screen on the centre-line.

The screen is then drawn to scale and split up into circular zones ; the number of zones is arbitrary and depends on the accuracy required, they should be narrowest where the rate of change of light density is the greatest. The area of each zone is calculated, the average light density in each zone read off the light-distribution curve, and the total lumens determined. Fig. 23 illustrates the working out of a practical example, using the diagrams in Fig. 22. This method of evaluating screen illumination is being investigated by a special committee of the B.S.I.

When taking light readings for comparative purposes, as many variables as possible must be eliminated ; the same instrument and same observer should be used, and porthole windows should be removed. Atmosphere conditions should as far as is possible be the same ; humidity and a trace of tobacco smoke, mist, or fog will have a big effect on the readings. Cases have been known where readings taken after the show at night and again the following morning have differed by as much as 20%.

So far, consideration has been given only to the incident light. That seen by the patrons is the light reflected by the screen, and this will vary widely with the nature and condition of the screen surface.

A cinema screen is a diffusing reflecting surface, that is to say, it does not reflect the light in a beam like the projector lanterns but scatters it over a very wide angle. A completely reflecting diffuse surface under an illumination density of one lumen per square foot (foot-candle) is said to have an average brightness of one " foot-lambert " which is the unit of brightness of any surface reflecting one lumen per square foot. The average brightness of any surface in foot-lamberts is the product of the illumination in foot-candles and the reflecting factor of the surface.

Light readings taken 6′ 3″ above lower edge of masking

No.	Foot-candles
1	16·3
2	21·5
3	22·7
4	21
5	16

Zone	Area sq. ft.	Mean light density Foot-candles	Lumens
Z 1	12·5	23·2	290
Z 2	100·5	22·5	2260
Z 3	137·0	19·7	2700
Z 4	138·0	16·2	2240
Z 5	44·0	11·5	500
Total area : 432 sq. ft.		Total lumens 7990	

Fig. 23. A practical example of the evaluation of screen illumination, based on the diagrams in Fig. 22.

An instrument for indicating relative screen brightness has been developed by the Morgan Crucible Co. Ltd. and is known as a " Reflectometer." It is usually fixed in one of the projection room portholes, and it consists of a lens which focuses an image of the illuminated screen onto the cathode of a photoelectric cell, variations in screen brightness causing a change in the P.E.C. current which can be indicated on a microammeter.

This instrument is ideal for checking lantern operation, as the optimum conditions for maximum screen brightness can be determined easily with its use, and, if it is installed as a permanency, it will give an indication of deterioration in lantern mirrors, screen reflectivity, and any other factors affecting screen brightness.

While the instrument indication is proportional to screen brightness, it is not very suitable for determining absolute values of lumens reflected by the screen, as the correction factor for calibrating the instrument in terms of total lumens is subject to many variables which are difficult to assess.

THE S/U/P/A PROJECTOR (cont'd.)

S/U/P/A PROJECTOR LANTERNS

There are two ratings of the S/U/P/A projector lantern, 75 amp. and 50 amp., the only differences between the two being the focal length of the mirror, and the size and current-carrying capacity of the carbon holders and their connections.

The lantern optical system employs an ellipsoidal mirror and has an aperture value of not more than f 1·9 in the case of the 50-amp. lantern, and f 1·7 in the case of the 75-amp. lantern, so that full advantage can be taken of the improved projection lenses which all have aperture values of f 1·9 or less.

The mirrors have a diameter of $14\frac{1}{2}''$, this value having been chosen after a study of the polar curve of light emitted from present-day carbons. The diameter of the mirror and its curvature provide a collecting angle which collects all the useful light emitted from the carbon crater.

Although the new mirror more completely envelopes the arc than in the case of earlier designs, an efficient magnetic arc control and a retractable mirror shield, which completely surrounds the arc during striking, effectively protect the mirror from overheating and damage during arc-striking. Fig. 24 is an illustration of the lantern chassis. Specifications of the two lanterns are given in Table I :—

TABLE I

	Lantern Type	
	H 2	K 2
Supply voltage	60-100 v.	80-100 v.
Arc voltage	40 volts	48-50 volts
Arc current	50 amps.	75 amps.
Positive carbon	7mm. × 18"	10mm. × 18"
Negative carbon	6mm. × 8 or 12"	7mm. × 8 or 12"
Positive burning-rate....	11" per hour	$9\frac{1}{2}''$ per hour
Negative burning-rate	4" per hour	4" per hour
Lantern aperture value	f1.9	f1.7
Mirror diameter	$14\frac{1}{2}''$	$14\frac{1}{2}''$
Minor focal length	$4\frac{5}{8}''$	$5\frac{3}{8}''$
Major focal length	$32\frac{3}{8}''$	$33\frac{1}{8}''$ (with lens)

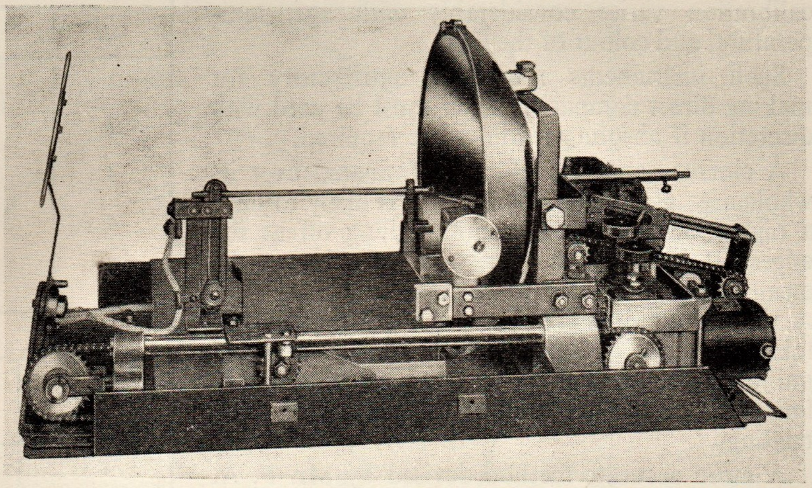
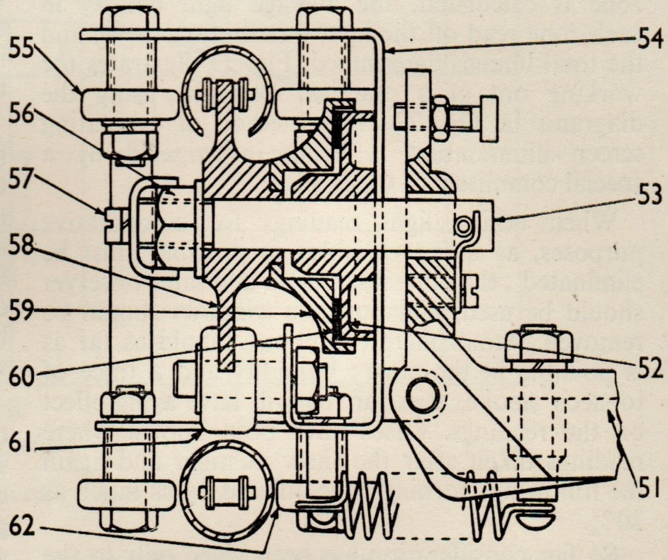


Fig. 24. Type H 2 lantern chassis.

A nose lens is used with the 75-amp. lantern thereby reducing the aperture value and increasing the convergence of the light beam, so that the distance from the back of mirror to gate is the same as the 50-amp. lantern for approximately the same size of crater image at the gate aperture.

The Positive Carriage

The positive moving carriage runs on ball-bearings and is driven by an endless chain running the full length of the lantern chassis. The teeth of a small sprocket, attached to the positive carriage and normally locked on its spindle, engage with the chain and the carriage is moved slowly towards the mirror as the chain moves.



51. Bracket carrying positive head.
52. Bearing.
53. Retaining stud.
54. Carriage.
55. Rollers.
56. Adjusting nut.
57. Lock-screw.
58. Sprocket.
59. Clutch plate.
60. Friction washer.
61. Roller.
62. Rollers.

Fig. 25. Cross-sectional view of Positive Carriage.

The chain is protected by two tubes, one of which has a longitudinal slot cut in its underside so that the carriage sprocket can engage with the chain. The chain passes over a sprocket driven by the lantern gearbox, at the back of the chassis.

A cross-section of the moving positive carriage is shown in Fig. 25. The weight of the positive carbon clamp at the end of bracket 51 assisted by a tension spring draws the stud 53 to the right and in so doing forces the clutch plate 59 fixed to the sprocket 58, against friction washer 60 ; the sprocket is thus locked and the movement of the driving chain is transmitted normally to the positive carriage.

If the bracket is lifted the clutch is freed and the carriage may be moved rapidly forwards or backwards as desired, being locked again immediately the bracket is dropped.

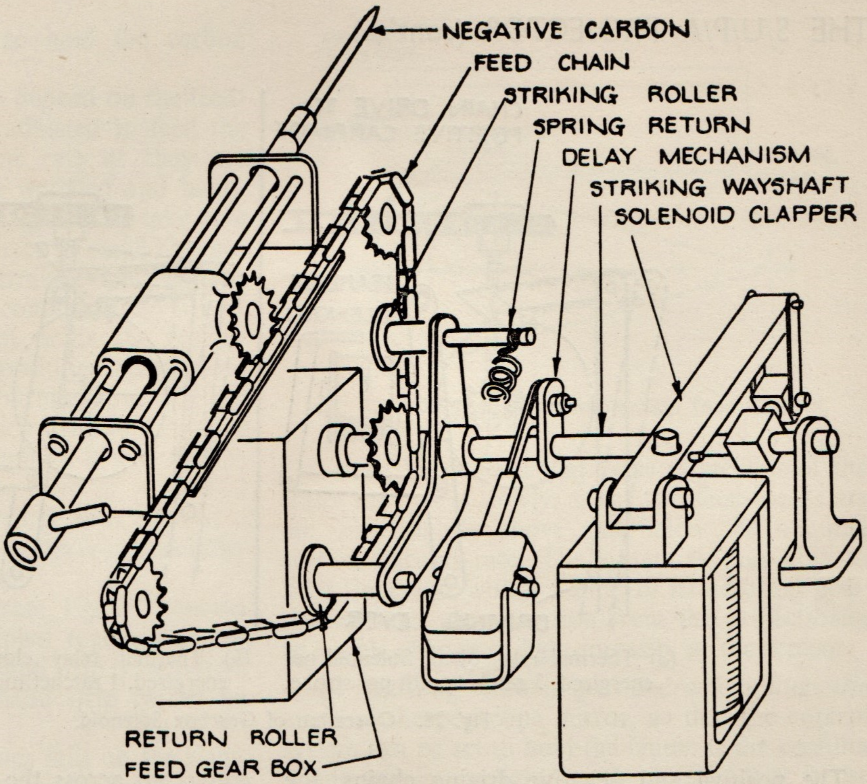


Fig. 26. Negative carbon-feed and striking mechanism.

If, due to wear of the friction washer, the positive carbon falls below the optical axis of the lantern, this may be corrected by slackening the locking-screw 57, tightening nut 56 the requisite amount to bring the positive carbon to its correct position, and then retightening locking-screw 57.

The Negative Carriage

The negative carbon carriage is also chain-driven by another chain-sprocket on the same gearbox ; the chain and negative carriage are moved forward by the striking solenoid to provide the automatic striking feature. Fig. 26 shows diagrammatically the negative carbon feed and striking mechanism.

The carbon holder is in the form of a tube with a collet at the end ; by rotating a lever at the back of the tube through about 90°, the collet firmly grips the negative carbon.

The carriage moves forward or backwards on fixed guide rods. By unlocking a quick-acting clamp at the side of the carriage, the latter is released from the driving chain and can be set in any desired position to give the correct arc-gap, and then re-clamped. The position of the negative carbon-tip can be adjusted by two external control knobs on the operating side of the projector ; these two knobs are on the same axis, and are marked " Up-Down " and " Right-Left," referring to movements of the carbon tip as viewed from the rear.

Fig. 27 is a diagram of the automatic striking circuit. On pressing the " STRIKE " push-button on the control panel, the main contactors close, and the arc supply is connected to the striking solenoid and arc carbons. When the striking solenoid is energized, its armature rotates a lay shaft which feeds forward the negative carriage until the carbons touch. As soon as currents flow in the main arc circuit, a series relay disconnects the striking solenoid, and the negative carriage is returned by a damped spring to its normal position, drawing the arc with it.

The arc is normally struck at 60% of full load current, and when the " RUN " push-button is pressed the current is brought up to its full value. If the lantern is operated in conjunction with a choke-controlled rectifier having a separate circuit for each lantern, the arc is struck at full load current.

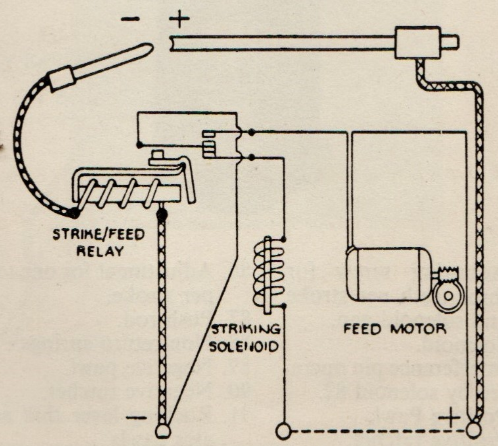
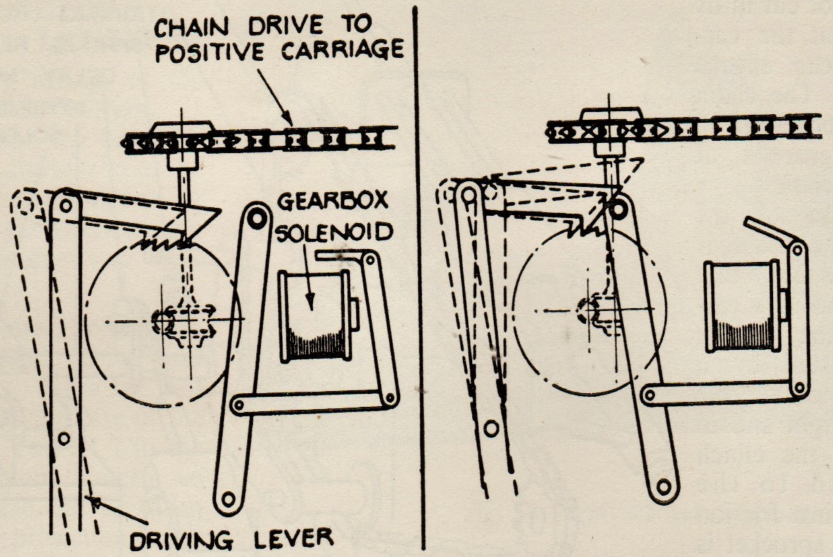


Fig. 27. Arc-striking solenoid circuit.

THE S/U/P/A PROJECTOR (cont'd.)



(*a*) Thermal relay open. Solenoid not energized. 3 ratchet teeth per stroke.

(*b*) Thermal relay closed. Solenoid energized. 1 ratchet tooth per stroke.

Fig. 28. Operation of Gearbox Solenoid.

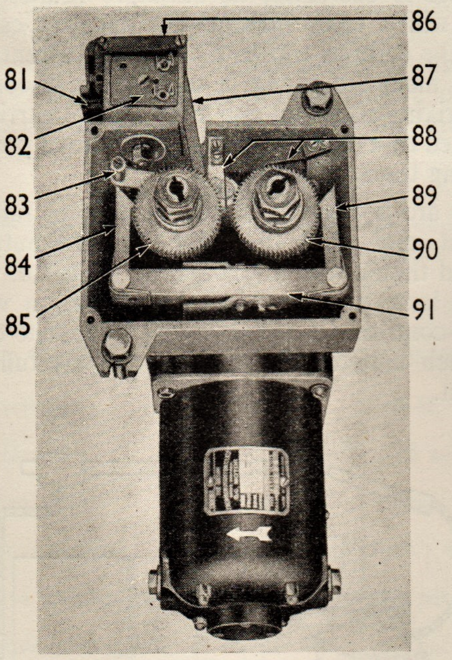
The positive and negative driving chains, the gearbox, and the hand-feed knobs can be seen in Fig. 24.

The Gearbox

The arc feed motor is a plain shunt-wound motor connected across the arc, the voltage of which is 42 volts in the case of the 50-amp. lantern and 50 in the case of the 75-amp. lantern. The motor end-shield is mounted directly on the side of the gearbox. The motor drives an oscillating lever through a worm reduction gear, and at each end of this lever is a pawl. One pawl engages with a ratchet wheel which drives the negative carriage, and the other with another ratchet wheel which drives the positive carriage.

The positive pawl normally rotates its ratchet wheel an amount equal to the pitch of three teeth for each stroke, the gear ratio being arranged so that this feeds the positive carbon forward faster than the burning-rate. A movable pin, operated by a relay, can be made to lift the pawl away from the ratchet wheel, thus limiting its action and rotating the ratchet wheel an amount equal to only one tooth each stroke, and so feeding the carbon forward rather slower than the normal burning-rate. The arrangement of the oscillating lever, ratchet wheels, pawls, and positive pawl-control pin can be followed from the diagram Fig. 28 and illustration Fig. 29.

Detachable control knobs are fitted to each ratchet wheel to provide hand control when initially trimming the carbons after recarboning. The ratchet wheels are coupled to their spindles through friction clutches so that the hand-control knobs can rotate the spindles against the normal direction of rotation if required.



81. Adjusting screw for three teeth per stroke and solenoid gap.
82. Solenoid.
83. Interference pin operated by solenoid 82.
84. Positive Pawl.
85. Positive ratchet.
86. Adjustment for one tooth per stroke.
87. Push-rod.
88. Non-return springs.
89. Negative pawl.
90. Negative ratchet.
91. Rocking lever that actuates pawls.

Fig. 29. Top view of Motor and Feed Ratchets.

Thermo-optical Feed Control

A projector lantern optical system employing an ellipsoidal mirror has only one position of the carbon crater for maximum light output, that is at the minor focal point of the mirror. It is the object of all feed-control systems to hold the carbon crater in this position.

Feed-control systems which depend on the feed-motor speed being carefully adjusted to feed the carbons forward at the same rate as they are consumed always have to be watched and hand-trimmed, as these systems are unable to take care of the many variable factors, such as small changes in arc current, carbon burning rate, lantern temperature, and ventilating conditions.

The thermo-optical control holds the carbon crater in one pre-determined position, independent of variations in the carbon burning rate. Fig. 30 shows the optical system which collects an image of the side of the crater, magnifies it and reflects it at 90° on to the bimetallic strip of a thermal relay. This constitutes an optical lever so that a small movement of the carbon crater is considerably magnified at the thermal relay.

The thermal relay (see diagram, Fig. 31) consists of two bimetallic strips coupled together at the top ; the bottom of the right-hand strip is anchored, and the bottom of the left-hand strip carries an electrical contact.

When the image of the crater falls on the right-hand strip, the heat of the crater causes the strip to bow and the contact on the left-hand strip to open. Under this condition, the positive-feed pawl moves the ratchet wheel three teeth per stroke. As the carbon is fed forward, the crater image passes from the right-hand strip, which cools, on to the left-hand strip which is now heated, causing it to bend and close its contacts ; this action energizes the gearbox relay, operating the pin which restricts the action of the positive pawl. The ratchet wheel is now moved only one tooth per stroke and the carbon crater slowly recedes.

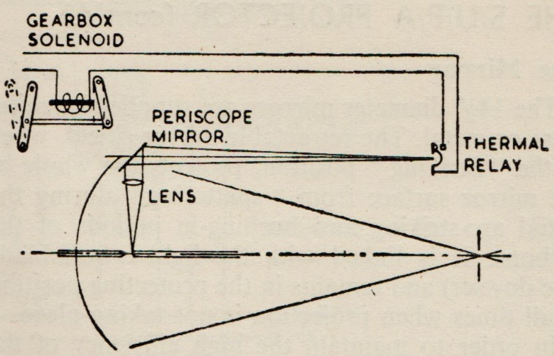


Fig. 30. Diagram of Thermo-optical Feed Control.

It must be realized that these excursions of the crater take place slowly, as the two feed-speeds are are only slightly above and below the nominal carbon burning-rate. The system is thus able to hold the crater within 1 mm. of its adjusted position without any attention from the projectionist or visible change of light-intensity at the screen.

An adjusting screw is provided which alters the angle of the periscope mirror, so that the control system can be set to hold the crater at the position giving maximum light on the screen, that is the minor focal point of the mirror.

The negative feed-rate is controlled by adjusting the motor speed, and is not as critical as the positive feed. When once adjusted, the arc length will remain constant even though there may be slight variations in positive carbon burning-rate.

The improvement in the lantern optical system as regards light collection angle and aperture value, the improved flicker shutter efficiency, and the new range of projection lenses of f 1·9 or better result in very high light intensities on the screen.

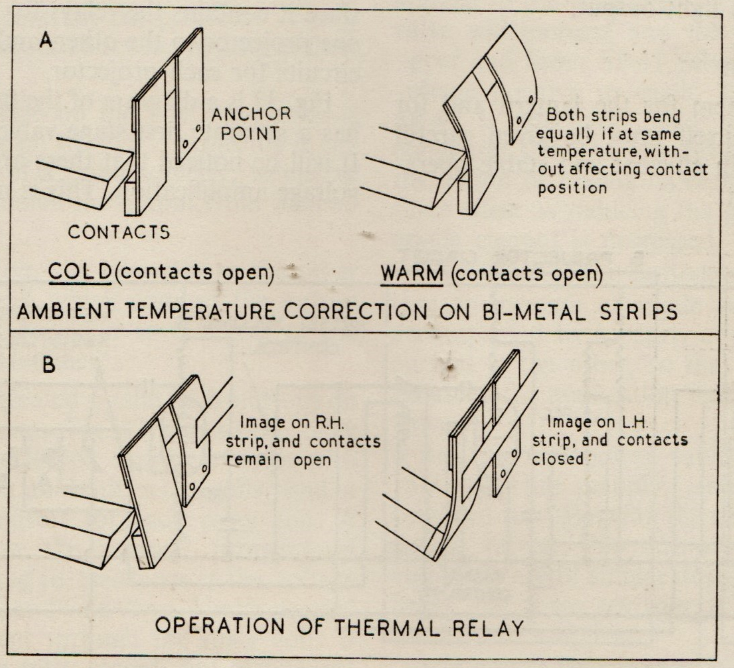


Fig. 31. Principles of Operation of Thermal Relay.

THE S/U/P/A PROJECTOR (cont'd.)

The Mirror

The 14½″ diameter mirrors are supplied in either glass or metal. The retractable mirror-shield, when in the " Striking " position, protects the whole of the mirror surface from " spattering " during the initial arc-striking and burning-in periods of the carbons. It is linked with the light-cut-off blade (the dowser) and remains in the protecting position at all times when projection is not taking place.

In order to maintain the high efficiency of the reflecting surface of the metal mirror, it must be cleaned daily with Silvo ; clouding that may occur due to faulty ventilation must be removed by the special rouge paste recommended.

The mirror is mounted in a cradle which can be tilted or slewed by means of two external knobs engraved " Down-Up " and " Left-Right," indicating the resultant movement of the light-beam on the screen.

General Features of the Lantern

Other features of the lantern are a large flat tray which can easily be cleaned or removed and which covers the whole of the bottom of the lantern. A 15-watt lamp is fixed inside the lantern housing to facilitate recarboning, cleaning, and inspection.

All the lantern doors hinge upwards and lock automatically in the raised position ; they are lowered by pushing the locking pin out of engagement. A carbon indicator on the outside of the lantern below the door indicates the length of carbon still available between the moving positive head and the carbon crater. An image of the arc and carbons is projected on to a ground-glass screen mounted in the operating-side door ; index marks on this screen shows the correct position of carbons for maximum light output.

Lantern Ventilation

The ventilation system for the lantern and for the projection room itself must be given careful consideration to obtain efficient and stable operation of the equipment.

The projection room should be adequately ventilated to prevent pockets of foul air accumulating in the ceiling near the lantern ventilators, as such conditions can affect the air flow through the lanterns. Bad projection-room ventilation will also cause a heavy deposit of carbon " bloom " on all parts of the projection equipment and will probably be ultimately the indirect cause of an electrical fault.

The lantern ventilating system has to perform two functions ; one is to produce a steady flow of air through the lantern to keep it cool and to carry away the arc fumes ; and the other is to prevent disturbances to the normal air stream due to weather conditions producing " down-draughts." Cases have occurred where due to unsatisfactory ventilating arrangements, the arc has been actually extinguished by a severe down-draught.

If the air flow through the lantern has too great a velocity, the carbon burning rate will be greater than normal and the arc will be liable to flicker ; the outlet chimney of the projector lantern is fitted with a flue damper which provides a means of controlling the air flow.

AMPLIFIERS

The Fader Amplifier

No fader in the form of a separate peice of apparatus is needed with S/U/P/A equipment, since each projector control panel has its independent volume control. Automatic changeover of light and sound is accomplished by pressing the changeover button on the front of the top spoolbox of either projection unit.

What was previously known as a voltage amplifier is now described as a fader amplifier, since it contains the relays for changing over from one projector to the other, and the volume control circuits for each projector.

Fig. 32 is a diagram of the fader amplifier, which has a separate first stage valve for each photocell. It will be noticed that there are only two stages of voltage amplification. This is made possible by the

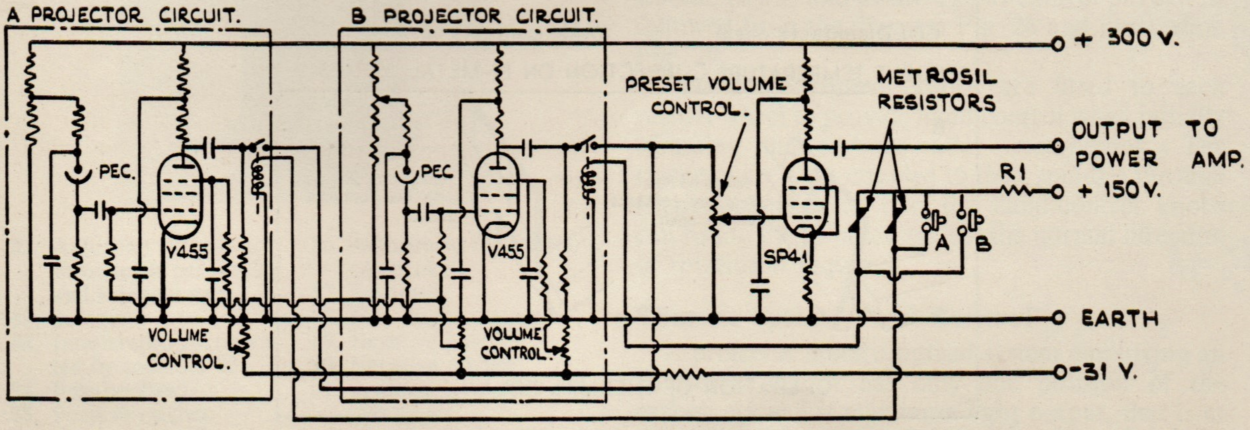


Fig. 32. S/U/P/A Fader Amplifier Circuit.

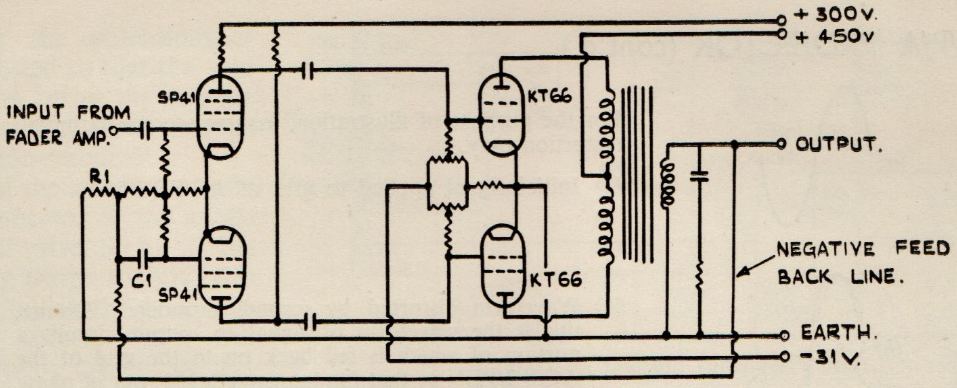


Fig. 33. S/U/P/A Power Amplifier Circuit.

efficient sound optical system which gives greater output from the photocell, and by the use of special low capacitance coaxial cable between the photocell and first valve. The arrangement permits the use of a high value for the photocell load resistance, and renders a photocell transformer unnecessary.

Volume control at each projector is obtained by varying the suppressor grid bias on the first V 455 amplifying valve. For zero volume the bias is a maximum and no signals can pass through the valve, the amplitude of the signal gradually increasing as the bias is reduced. This system has the advantage that any noise introduced by the P.E.C., input connections, and first valve are reduced with the signal, whereas volume controls which are in the signal grid circuit only control the signal amplitude, the noise level remaining constant at its maximum value.

Another advantage is that the volume control circuit is of low impedance and is therefore not liable to pick up noise from extraneous interference.

There is a preset volume control in the grid circuit of the second SP 41 amplifying valve. This is set on installation to suit auditorium conditions so that in normal operation the projector volume controls are usually set at about the middle of their scales.

The P.E.C. excitation on the " A " projector is fixed at 88 volts, but on the " B " projector it can be varied by means of a potentiometer, to enable the projectionist to match the output from the two P.E. Cells.

The changeover from one projector to the other is made by two relays, which connect the output of one or the other projector to the grid of the second valve in the amplifier.

These relays are operated by the push-buttons on the projector spoolboxes. Fig. 32 shows both relay coils connected to a 150-volt supply in series with a resistance common to both relay coils, and a separate Metrosil resistor for each relay coil. A Metrosil resistor has the unusual property of considerably increasing its resistance if the voltage across it is decreased, and vice versa. Under normal conditions, the current through the relay coils is sufficient to hold the relay closed, but insufficient to close it if it is open.

The diagram shows the " A " projector relay closed and " B " projector relay open. If the " B " push-button is pressed, it short-circuits the Metrosil in series with " B " relay ; this increases the current in the relay sufficient to close it and connects " B " projector to the amplifier. This increase in current causes a bigger voltage drop across the resistance R_1, thus reducing the voltage across " A " relay and its Metrosil. This causes the " A " Metrosil to increase in resistance and to reduce still further the current in " A " relay, which drops out and disconnects " A " projector from the amplifier.

The Power Amplifier

This is a push-pull amplifier of a rather unusual form, as transformers have been eliminated from the amplifier circuit to avoid distortion and losses. The only transformer used is the power output transformer.

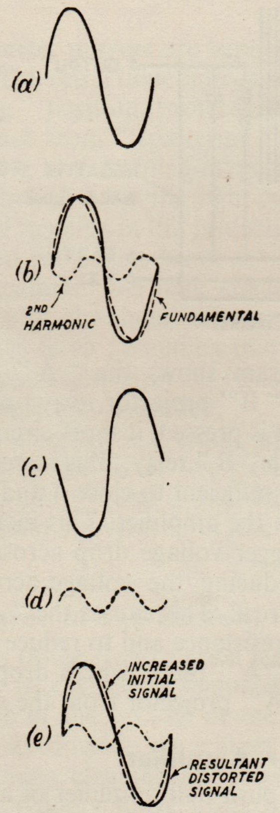
The essential circuits of the power amplifier are shown in Fig. 33. The two driver valves have a common cathode resistor chain, the input signal being applied directly to the grid of the upper SP 41 driver valve. Assume a positive-going signal is applied to the grid, then the anode current of this valve will increase and the cathodes of both the upper and lower SP 41 valves will rise to a higher voltage positive to earth. The grid of the lower SP 41 is effectively held at earth potential by condenser C 1 and low resistance R 1 ; therefore, the action of raising its cathode potential has the same effect as reducing the grid potential, and the anode current is decreased.

The values of the cathode resistors are so chosen that an increase of anode current in one valve is accompanied by a nearly equal decrease of anode current in the other, so that a push-pull action is obtained for application to the grids of the power valves.

Bias for the power valves is obtained from a 35 v. negative supply, and potentiometers are provided for balancing the quiescent current of the power valves. The 45-watt and 90-watt power amplifiers are of similar design, the main difference being that there are four KT 66 output valves in the 90-watt amplifier.

The output transformer is wound for a 500-ohm load impedance. A correction network is included

THE S/U/P/A PROJECTOR (cont'd.)



For the purpose of illustration, assume second harmonic distortion only.

(*a*) Initial signal applied to grid of AC/S 2/PEN.

(*b*) Waveform distorted by second harmonic. Assume this is the waveform of signal in output circuit, a portion of which is fed back on to the grid of the AC/S 2/PEN so that fundamental is 180° out of phase with the initial signal shown at (*a*).

(*c*) Distorted wave for feed-back on to the grid of the AC/S 2/PEN. This neutralizes the initial signal (*a*) and leaves only the second harmonic shown at (*d*).

(*d*) Second harmonic remaining on grid of AC/S 2/PEN.

(*e*) The initial signal (*a*) is increased in amplitude to compensate for the neutralized signal. This combines with the second harmonic (*d*), producing a distorted signal of such a waveform that it neutralizes the distortion introduced in the output circuit shown at (*b*).

Fig. 34. Principle of Operation of Negative Feed-back.

in the output circuit to provide negative feed back to the grid of one of the driver valves. The purpose of negative feed-back is to eliminate distortion in the amplifier ; the initial signal applied to the grid of the first valve is deliberately distorted in such a way as to neutralize any distortion which may occur in the output stage. The action is illustrated in Fig. 34. In the case of the S/U/P/A amplifier, the harmonic distortion is within 1% at all loads and frequencies.

Stabilized Power Supply

The KT 66 output valves in the power amplifier are high-efficiency beam-tetrodes. With this type of valve, it is essential that the screen voltage should be held constant, irrespective of variations in supply voltage and in the power being delivered by the valve. It is also desirable that the anode supply to the fader amplifier valves should be kept constant under all working conditions.

A stabilized power pack is used to supply these circuits. In addition to maintaining the voltage constant to within ± 1% over a wide range of input-voltage and output-load variations, this also forms an efficient ripple filter, thus effecting a reduction in the number and size of filter components required.

Fig. 35 shows the essential parts of the stabilized power pack. It consists of an orthodox full-wave rectifier followed by a choke and main smoothing condenser. At this point the 450 v. supply is taken off for the power valve anodes. Between this point and earth is connected an SP 41 valve, with a resistance in series with the anode and a 7475 neon stabilizer in series with the cathode. This is followed by a resistor and a KT 66 valve used as a triode, the cathode being connected to the 300 v. terminal.

The 7475 neon stabilizer has the property of maintaining constant volts across itself, independent of changes in current ; therefore the cathode of the SP 41 is kept at a constant voltage to earth (about 100 volts). The grid of the SP 41 valve is connected to a potential divider across the 300 v.

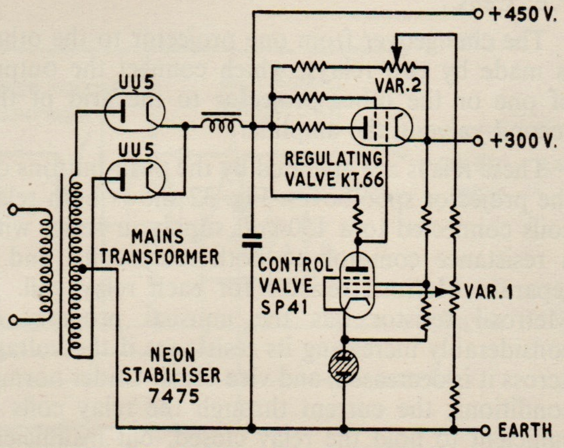


Fig. 35. Stabilized Power Supply Unit.

output, and the potentiometer VAR_2 is adjusted so that the grid is a few volts below the cathode and a small current flows through valve and neon stabilizer.

The grid of the stabilizing valve KT 66 is connected to the anode of the control valve, SP 41. If the 300 v. supply drops slightly, this will cause a fall in the grid voltage on the control valve, will reduce the anode current of this valve, and will reduce the negative bias on the control grid voltage of the stabilizing valve, thus reducing the impedance of the latter and restoring the 300 v. line to its nominal value. If the 300 v. supply increases, then the sequence of events is reversed.

The potentiometer VAR_2 varies the voltage regulation of the system and can be set to give a rising characteristic if desired. The potentiometer VAR_1 sets within limits the voltage at which the system stabilizes.

Deaf-aid Amplifier

A separate single-stage self-contained amplifier unit is used for deaf-aid headphones, the connections being shown in Fig. 36. The input is obtained from the power amplifier output transformer and the output is ample to supply up to 40 deaf-aid headphones.

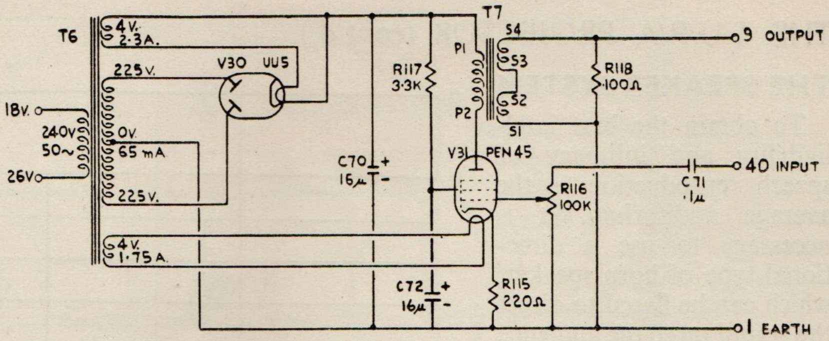


Fig. 36. Deaf-aid Amplifier Circuit.

Frequency Characteristics

The S/U/P/A amplifiers have been designed to have ample gain at all audible frequencies, so as to enable any desired frequency characteristic to be obtained. Cinema auditoria vary considerably in regard to their natural resonant frequencies, sound absorption characteristics and reflecting surfaces. It is therefore desirable to be able to adjust the frequency characteristic of a sound reproducer so as to produce the best results in any particular cinema.

A frequency correction network is introduced between the fader amplifier output and power amplifier input and by means of this the overall frequency characteristic can be adjusted over a very wide range.

The curves Fig. 37 show six typical frequency characteristics of amplifier output that can be obtained by adjustment of the correction network.

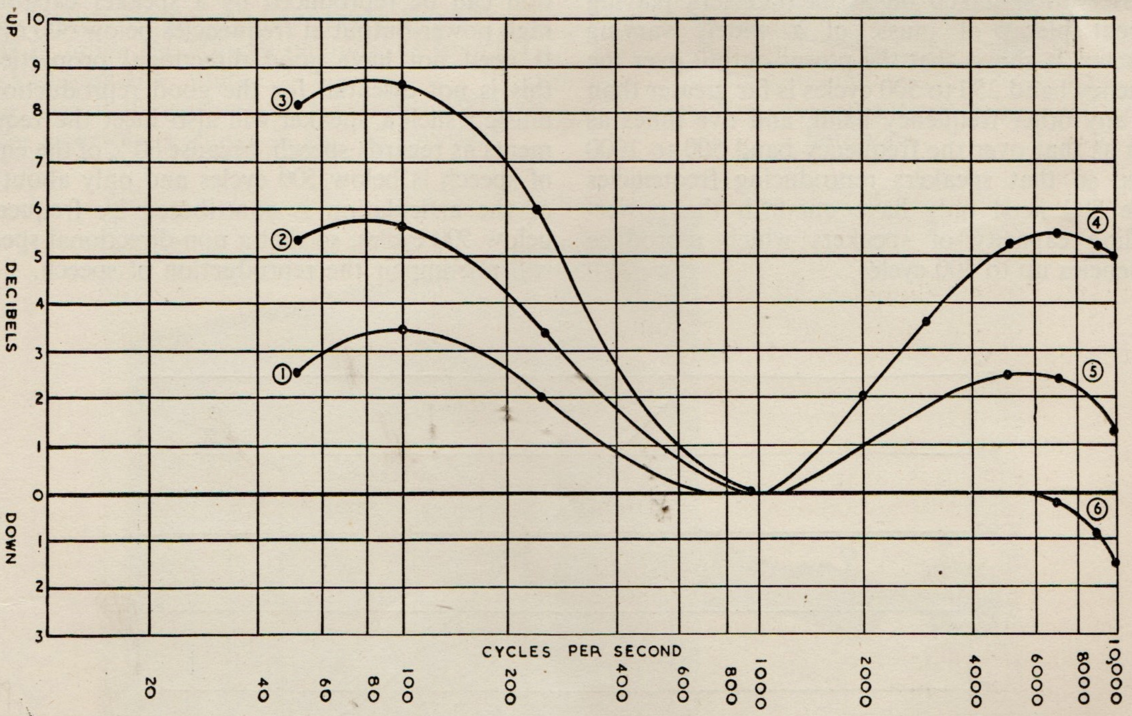


Fig. 37. Frequency Characteristics obtainable for 45-watt and 90-watt equipments.

THE S/U/P/A PROJECTOR (cont'd.)

THE SPEAKER SYSTEM

To obtain the best intelligibility and intimacy of speech reproduction in the average auditorium, it is necessary to use a directional type of horn speaker, which can be flared to direct the sound on to the audience and to keep it off reflecting surfaces such as walls and ceiling.

Efficient speaker units suitable for mounting behind an exponential horn have a small-diameter light-weight metal diaphragm which can be designed to have high output at the higher audible frequencies but are not capable of high-power output at low frequencies which require a large diaphragm excursion. A different type of speaker capable of high output at low frequencies is therefore used for low-frequency reproduction.

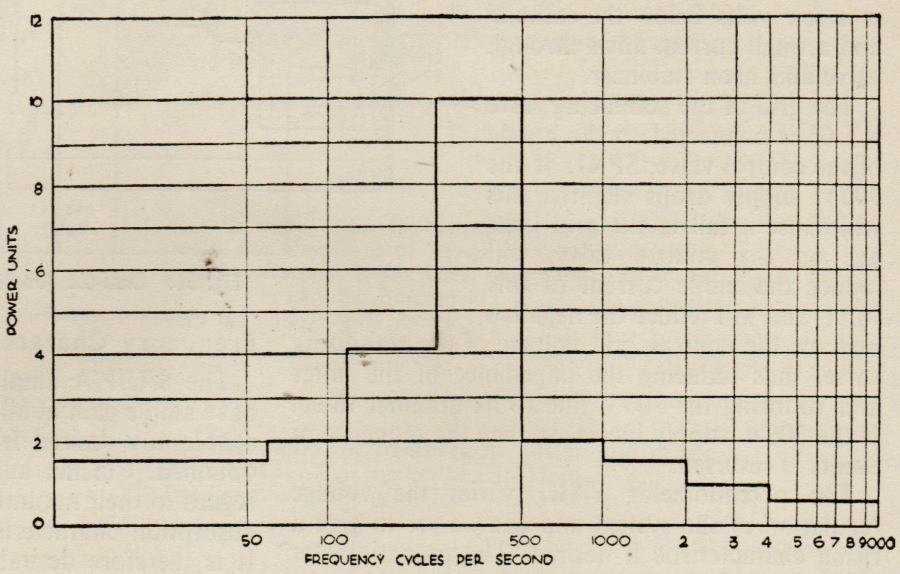


Fig. 38. Diagram showing power delivered by an orchestra.

There are a number of considerations which govern the selection of the frequency bands to be reproduced by the two different types of speakers in a combination of this type.

Fig. 38 is a curve of the average of a large number of observations taken on a full orchestra playing different pieces of music of a widely varying character. It shows that the power output over the frequency band 250 to 500 cycles is far greater than over any other frequency band, and five times as much as that over the frequency band 500 to 1000 cycles, so that speakers reproducing frequencies above 500 need only have one-fifth the power-handling capacity of speakers which reproduce frequencies up to 500 cycles.

With regard to the reproduction of speech, in Fig. 39 are two curves. One shows how much the various frequencies contribute to the articulation of speech, and shows that frequencies below 500 cycles contribute only about 2%. The other curve shows the energy at various frequencies in average speech reproduction and shows that 60% of the energy in speech is at frequencies below 500 cycles.

From these two sets of curves it will be seen that the greater portion of power in musical reproduction can be reproduced by a speaker capable of high power-output at frequencies below 500 cycles. It need not have good directional properties as this is not essential for the good reproduction of music ; such a speaker will also meet the requirements as regards speech, because 60% of the energy of speech is below 500 cycles and only about 2% of the articulation is contributed by frequencies below 500 cycles, so that a non-directional speaker will not impair the reproduction of speech.

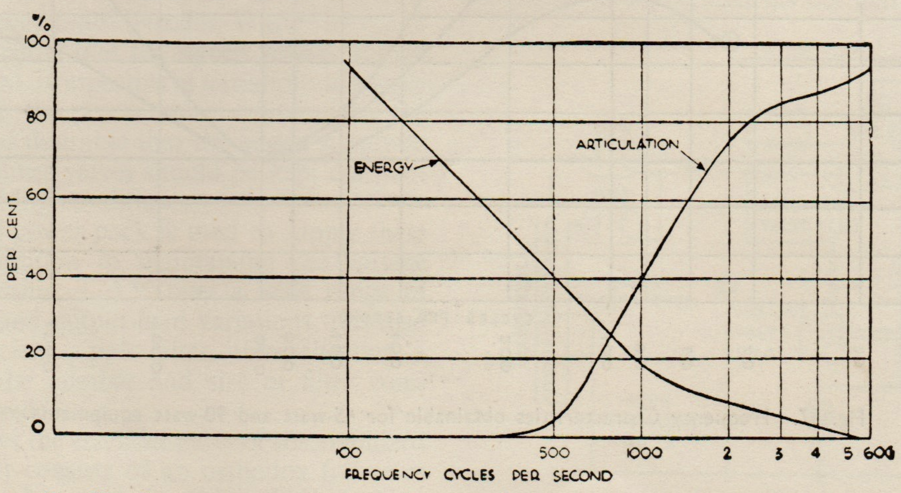


Fig. 39. Percentage contribution of various frequences to speech articulation.

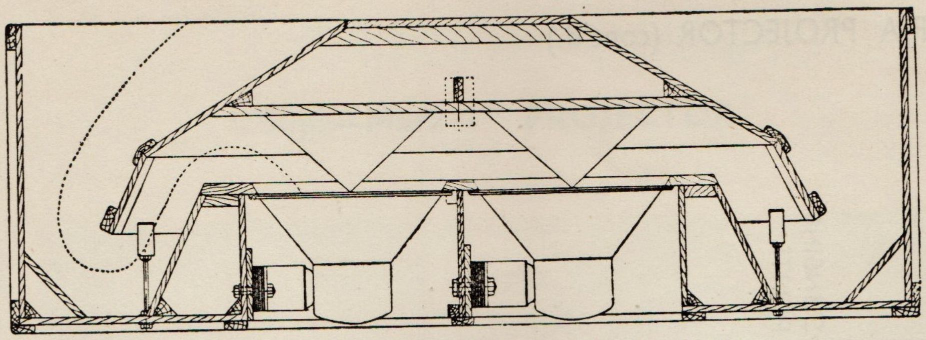


Fig. 40. Cross-section of Low Frequency Speaker Baffle.

Frequencies above 500 cycles which contribute nearly all the articulation in speech can be satisfactorily reproduced by a directional speaker with much lower power-handling capabilities.

The 500-ohm amplifier output line is connected to a frequency selector unit which has two output channels, one for frequencies below 500 cycles and the other for frequencies above 500 cycles. Frequencies below 500 cycles are connected to 15″ dia. moving-coil speaker units mounted in a wooden baffle of a cross-section similar to that shown in Fig. 40, which has an approximately exponential path from the speaker cone to the front of the baffle; Fig. 41 is a photograph of a typical installation, a two-unit Low Frequency baffle with a H.F. horn above it.

Frequencies above 500 cycles are connected to speaker units with a thin duralium diaphragm approximately 3 cm. diameter, mounted on a multicellular directional horn speaker of the type shown in Fig. 42.

The 45-watt equipments have two L.F. units and two H.F. units, the 90-watt equipments four L.F. units and four H.F. units.

The overall dimensions of a complete 90-watt speaker assembly is shown in Fig. 43 (overleaf).

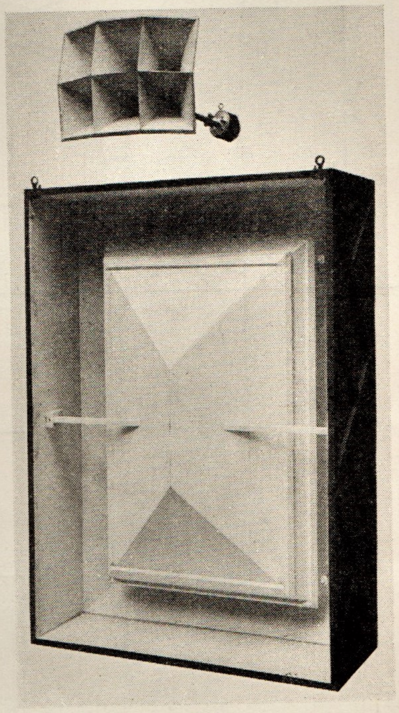


Fig. 41. Typical S/U/P/A Speaker Installation.

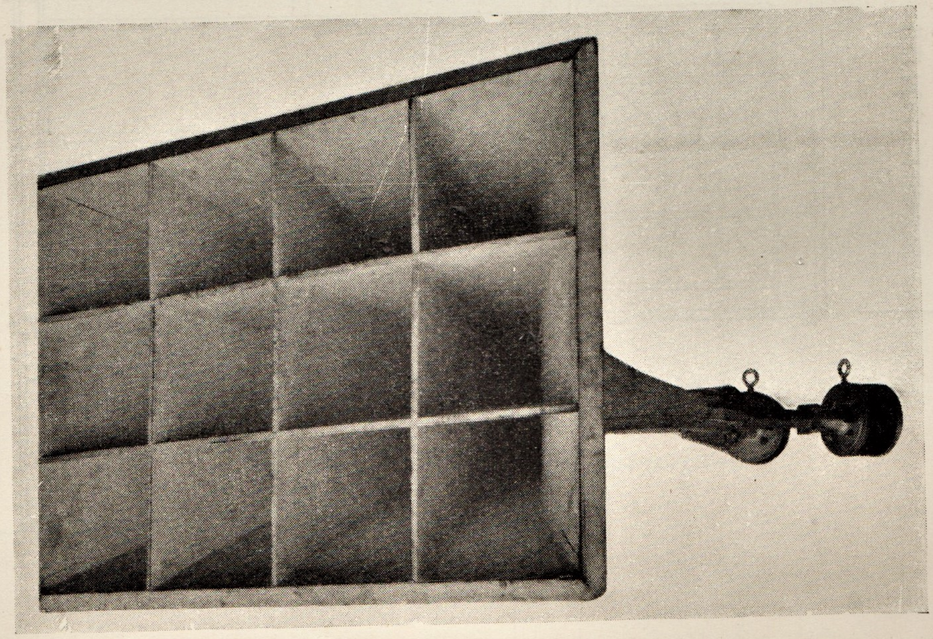


Fig. 42. Multicellular High Frequency Directional Speaker for 90-watt equipment.

THE S/U/P/A PROJECTOR (cont'd.)

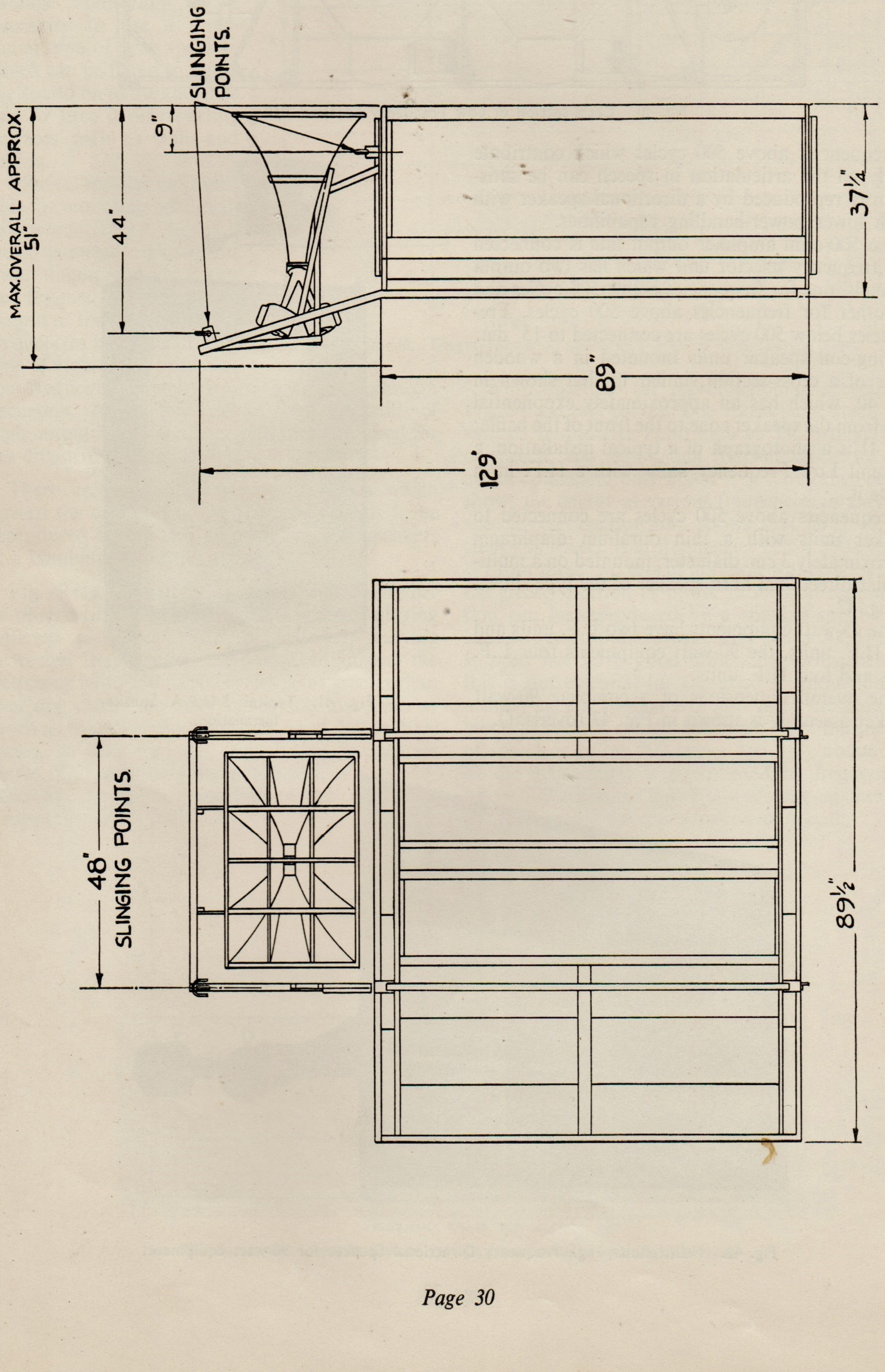


Fig. 43. Arrangement of 90-watt H.F. and L.F. Speaker Units and Baffles.

"Supa—Mark 2" PROJECTOR

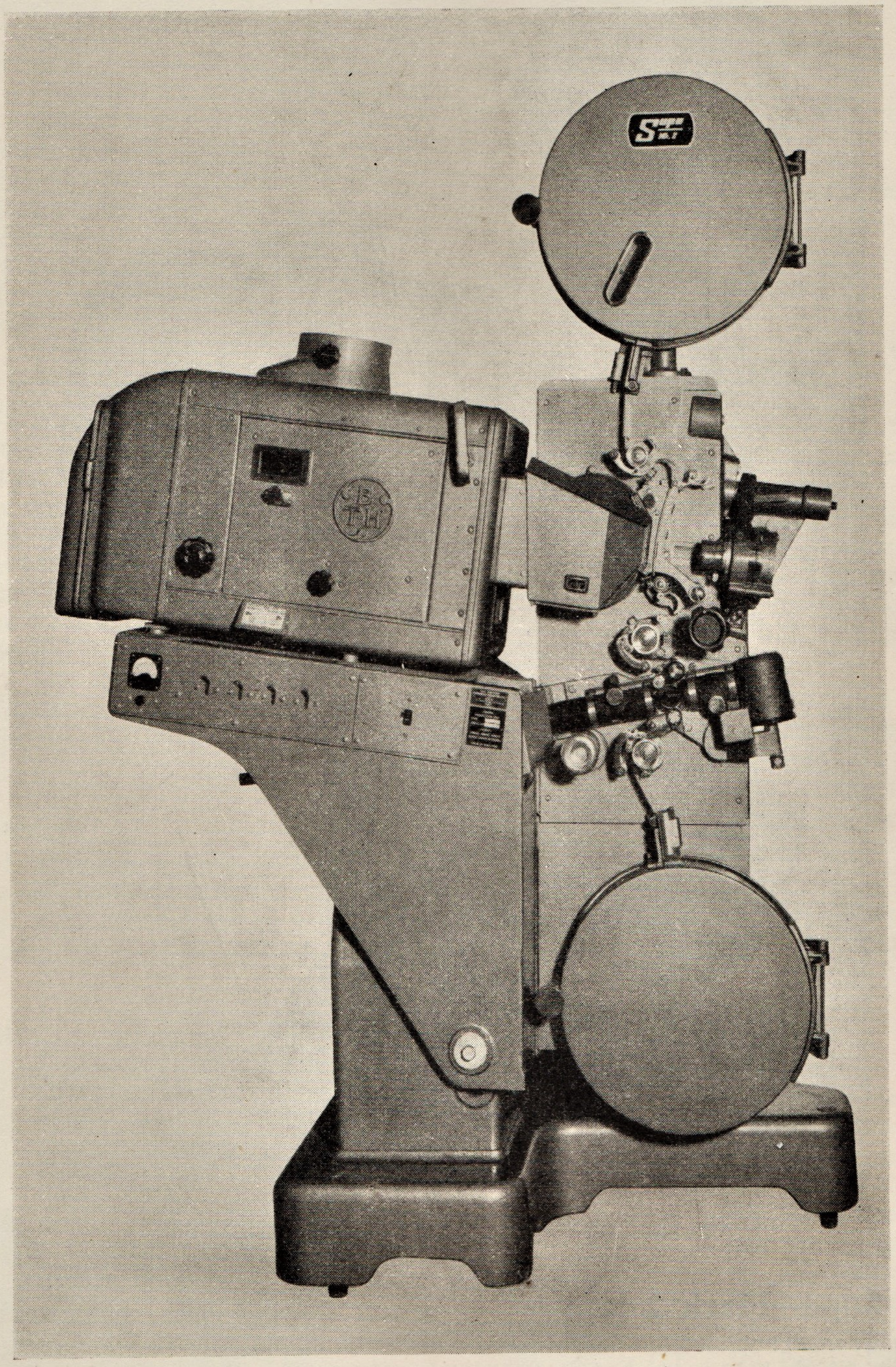


Fig. 44. "Supa—Mark 2" Projector, operating side.

"Supa—Mark 2" PROJECTOR (cont'd.)

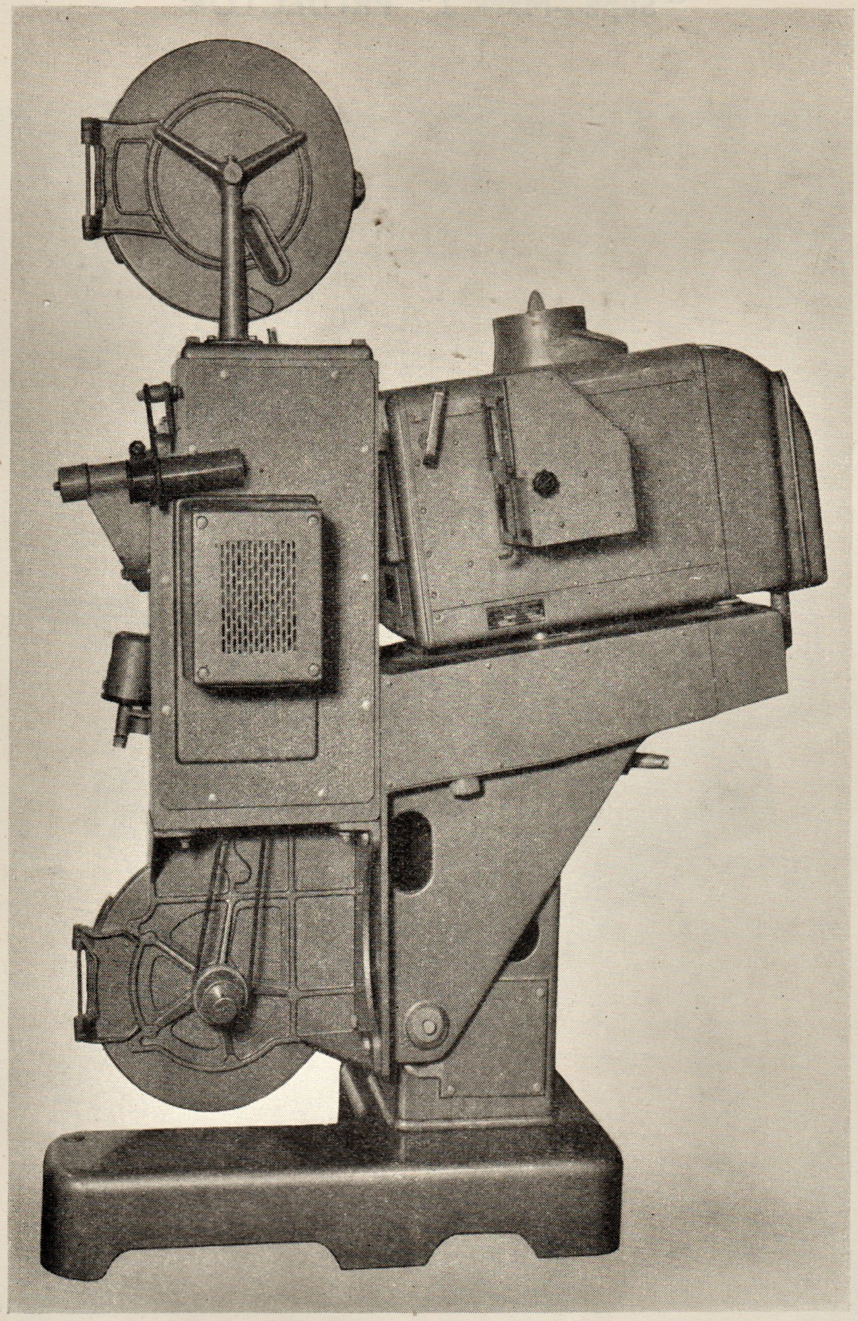


Fig. 45. "Supa—Mark 2" Projector, non-operating side.

Supa—Mark 2

There are many small and medium-sized cinemas where S/U/P/A's high light output, high-power sound output, and some of its automatic control features are not essential, but where the highest standard of sound quality and picture projection must be provided.

To meet this requirement a modified form of the S/U/P/A equipment has been developed, in which some of the refinements of the S/U/P/A equipment have been omitted to reduce cost, but all the important features which contribute to the high standard of performance have been retained.

General Arrangement

The S/U/P/A mechanism box is attached to a suitably-designed lantern table which supports a Type L projector lantern ; control switches are mounted on the operating side of the table. Standard-type circular spoolboxes are used.

The complete assembly is shown in Figs. 44 and 45.

The controls on the side of the lantern table are :—

Motor Starting Switch.
Arc Regulating Switches.
Meter, with push-button to read Arc Current or Arc Volts.

To suit variations in projection angle, the lantern table hinges about a pivot bar passing through the vertical column of the stand. It is held rigid by a rake-adjusting screw which covers a range of projection angles from 10° upwards to 25° downwards. To suit variations in porthole height, there are three holes at different heights in the vertical column for the pivot bar ; also, a range of distance pieces is available for insertion between the base and the stand column. The three jacking screws which form the feet of the base are adjustable for levelling and fine adjustment of height.

Mechanism Box

The S/U/P/A mechanism box is fitted, providing all the advantages of the S/U/P/A flicker shutter, curved gate, lens holder, sound drum unit, sound optical system, and other new features.

As with the S/U/P/A equipment, the large projection-lens holder can be fitted with an adaptor to take standard lenses with $2\frac{1}{16}''$ diameter barrel, aperture value f 2·0 and greater. The automatic electrically-operated changeover can, if desired, be replaced by a less expensive manually-operated changeover shutter, in which case the shutters on the two projectors are coupled together by a bowden cable.

Projector Lantern

The Type L Projector Lantern used with this equipment is a self-contained lantern complete with its housing. (It is suitable for use on any type of projector stand.) Its specifications are given in Table II.

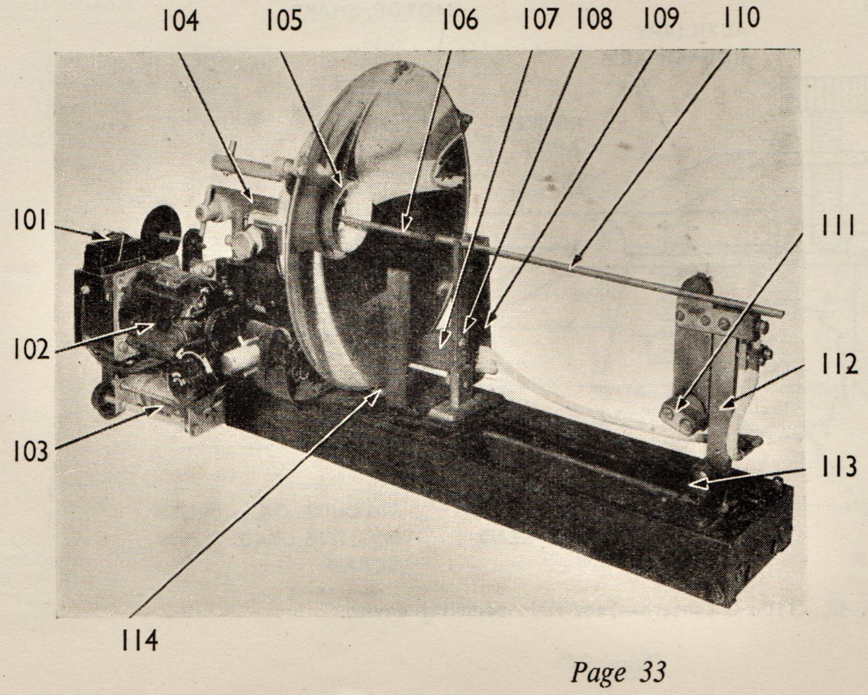
TABLE II

Supply Voltage	60-100 volts	
Mirror Diameter	12″	
Lantern Aperture Value	f 2·0	
Minor Focal Length	$4\frac{1}{2}$ in.	
Major Focal Length	31 in.	
Positive Carbon	7mm.×12″	8mm.×12″
Negative Carbon	6mm.×8″ or 12″	6mm.×8″ or 12″
Arc Current	40 amp.	50 amp.
Arc Voltage	32-35 volts	36 volts
Positive Carbon Burning-rate	10″ per hour	$9\frac{1}{2}''$ per hour
Negative Carbon Burning-rate	$3\frac{1}{2}''$ per hour	$4\frac{1}{2}''$ per hour

The chassis with mirror in position is shown in Fig. 46. The positive and negative carbon carriages are driven by lead screws which extend the full length of the chassis. At the back of the chassis each lead screw is fitted with a ratchet wheel and hand feed knob.

Both carbon carriages are fitted with quick-release devices for resetting purposes, and the negative carbon is provided with an external control at the back of the lantern to enable the carbon tip to be raised, lowered, or slewed sideways so that correct burning of the crater can be obtained.

Both carbon clamps are remotely operated so that new carbons can be fitted without burning the fingers.



101. Motor Fuses.
102. Feed Motor.
103. Speed-control Rheostat.
104. Negative Carriage.
105. Mirror Shield.
106. Negative Carbon.
107. Slag Tray.
108. Positive Guide.
109. Arc-control Magnet.
110. Positive Carbon.
111. Positive Clamp Knob.
112. Positive Carriage.
113. Resetting Knob for 112.
114. Bottom Location for Mirror.

Fig. 46. Chassis, Motor, and Control Unit.

"Supa—Mark 2" PROJECTOR (cont'd.)

Automatic Carbon Feed

The automatic feed mechanism is shown in Fig. 47. It is driven by a 40 volts D.C. motor through a worm and worm-wheel. The worm-wheel shaft carries an eccentric which, as it rotates, causes a rocker arm to oscillate about a pivot placed above and between the positive and negative carbon lead screws.

At one end of the rocker arm is attached a pawl 125, which engages with the ratchet wheel 128 on the positive lead screw; at the other end is a pawl 126, which engages with the ratchet wheel 127 on the negative lead screw, so that as the arm rocks, it rotates first one lead screw then the other.

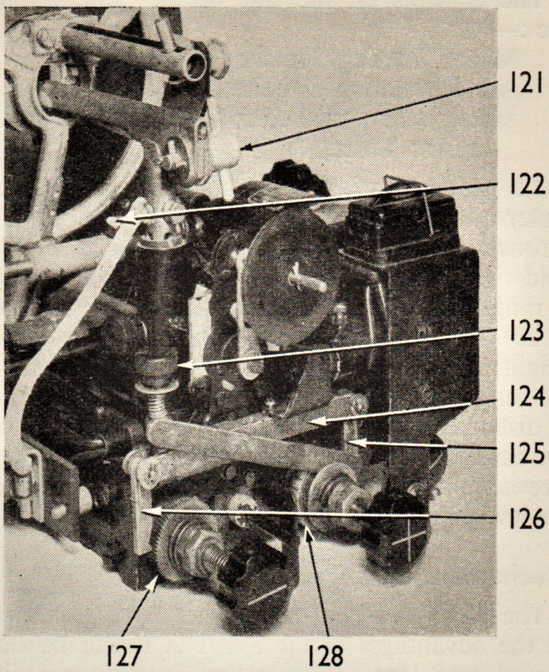
Means are provided for adjusting the ratio of positive and negative feed rates.

The operation of the feed-ratio adjustment is shown in the diagram Fig. 48. The negative pawl is not attached directly to the end of the main rocker but to a separate lever hinged on the same pivot. This lever is held against the rocker so that it normally follows the movement of the end of the rocker, thereby causing the negative pawl to oscillate and rotate the negative lead screw.

An auxiliary rocker arm is pivoted on the same pivot as the main rocker arm. One end of the auxiliary rocker arm is held in contact with an eccentric cam on the positive lead screw, the other end carrying an adjusting screw the end of which bears on the negative pawl lever.

As the eccentric cam rotates, it causes the adjusting screw to depress the negative pawl lever thus restricting the movement of the pawl and consequently reducing the rotation of the negative lead screw for each stroke of the pawl.

Normally the negative pawl rotates the ratchet wheel two teeth per stroke and when the lever is depressed only one tooth per stroke.



121. Negative Carbon Clamp.
122. Mirror-knob Spindle Clamp Screw.
123. Negative Feed Adjusting Knob.
124. Rocker Arm.
125. Positive Pawl.
126. Negative Pawl.
127. Negative Ratchet and Clutch.
128. Positive Ratchet and Clutch.

Fig. 47. Rear view of Lantern Chassis, gear cover removed.

By varying the position of the adjusting screw, the number of times that the pawl moves two teeth per stroke (for each revolution of the positive lead screw) can be varied, thereby changing the amount that the negative lead screw is rotated relative to the positive. The ratio can be varied from 1 : 1·5 to 1 : 1·33. The positive feed-rate is controlled by a rheostat in series with the feed motor's shunt field.

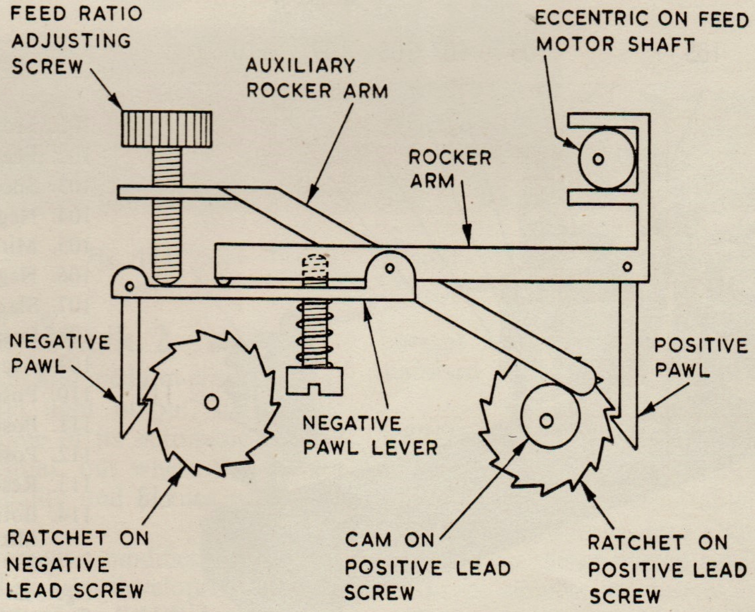


Fig. 48. Type L Lantern—Feed-ratio adjusting device.

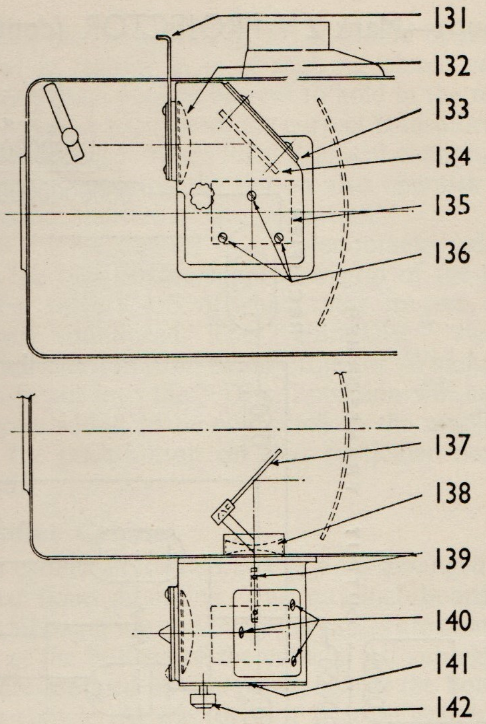
Mirror

The 12″ ellipsoidal mirror is mounted in a cradle which has provision for tilting or slewing the mirror by means of two concentric adjusting knobs on the operating side of the lantern. A retractable mirror shield, linked to the light cut-off, protects the mirror from spattering while arc-striking and burning-in the carbons. A heat-resisting nose glass is fitted in the front of the lantern to satisfy some local regulations and to protect the arc from the effects of draught.

Slide Attachment

A slide attachment can be provided when required for projecting lantern slides. It is attached to the non-operating side of the lantern as shown in Fig. 49, and is brought into operation by the handle which normally operates the mirror shield and light cut-off. With the cut-off closed, the handle is pushed inward, coupling it to a swinging mirror, 137. Rotation of the handle swings the mirror to intercept the light beam and to reflect some of the light on to the negative lens 138. Passing through this lens the light is deflected by two plane mirrors, 134 and 135, on to a condenser lens, 132, immediately behind the slide carrier. When the handle is again rotated, the device is reset for normal film projection.

The slide lens carrier can be attached to the mechanism box and one porthole made large enough to project both film and slides.



131. Slide Carrier.	137. Swinging Mirror.
132. Condenser Lens.	138. Negative Lens.
133. Top Cover.	139. Stop for 137.
134. Upper Mirror.	140. Upper Mirror Adjusting Screws.
135. Lower Mirror.	141. Side Cover.
136. Lower Mirror Adjusting Screws.	142. Shutter Knob.

Fig. 49. Arrangement of Slide Attachment.

The Sound System

The layout of this equipment is shown in Fig. 50.

The signal from the P.E. cell is fed into a 6F 11 valve connected as a cathode follower which is mounted in the P.E.C. housing. The low impedance output from this valve is taken through coaxial cable to the input switch mounted on the front wall of the operating box. This switch gives a choice of film or non-synchronous sound.

The output from the pick-up on the non-synchronous equipment is fed into a separate 6F 11 valve on the amplifier chassis, and the non-synchronous sound level is thereby adjusted to match that from the film channel. The amplified non-synchronous signal is taken through coaxial cable to the input switch.

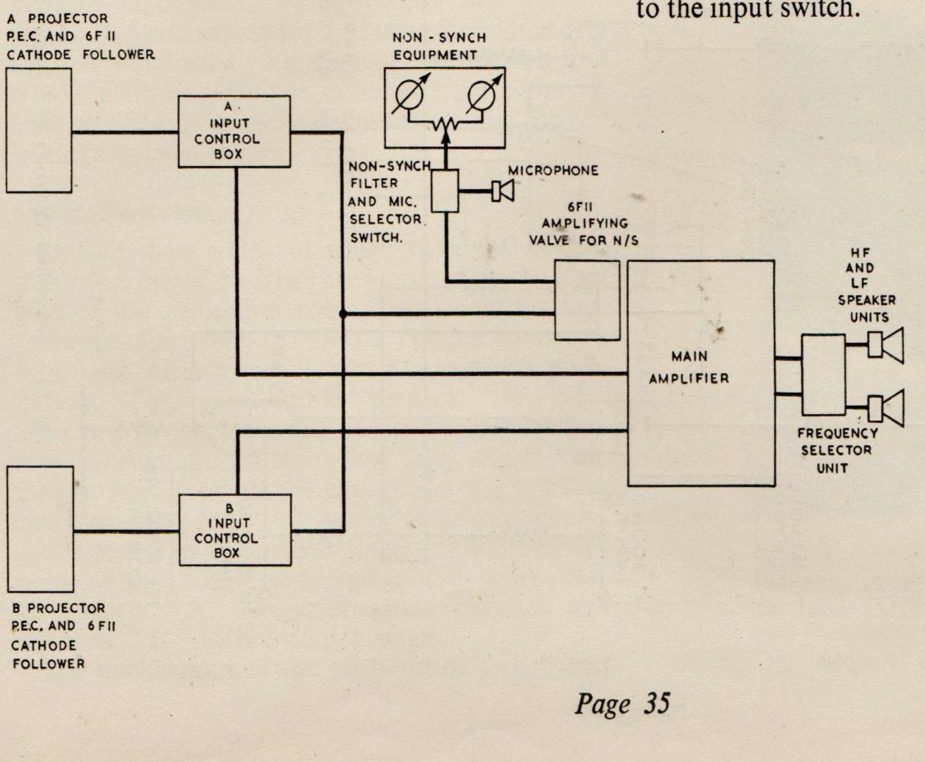


Fig. 50. Diagrammatic Layout of "Supa—Mark 2" equipment.

"Supa—Mark 2" PROJECTOR (cont'd.)

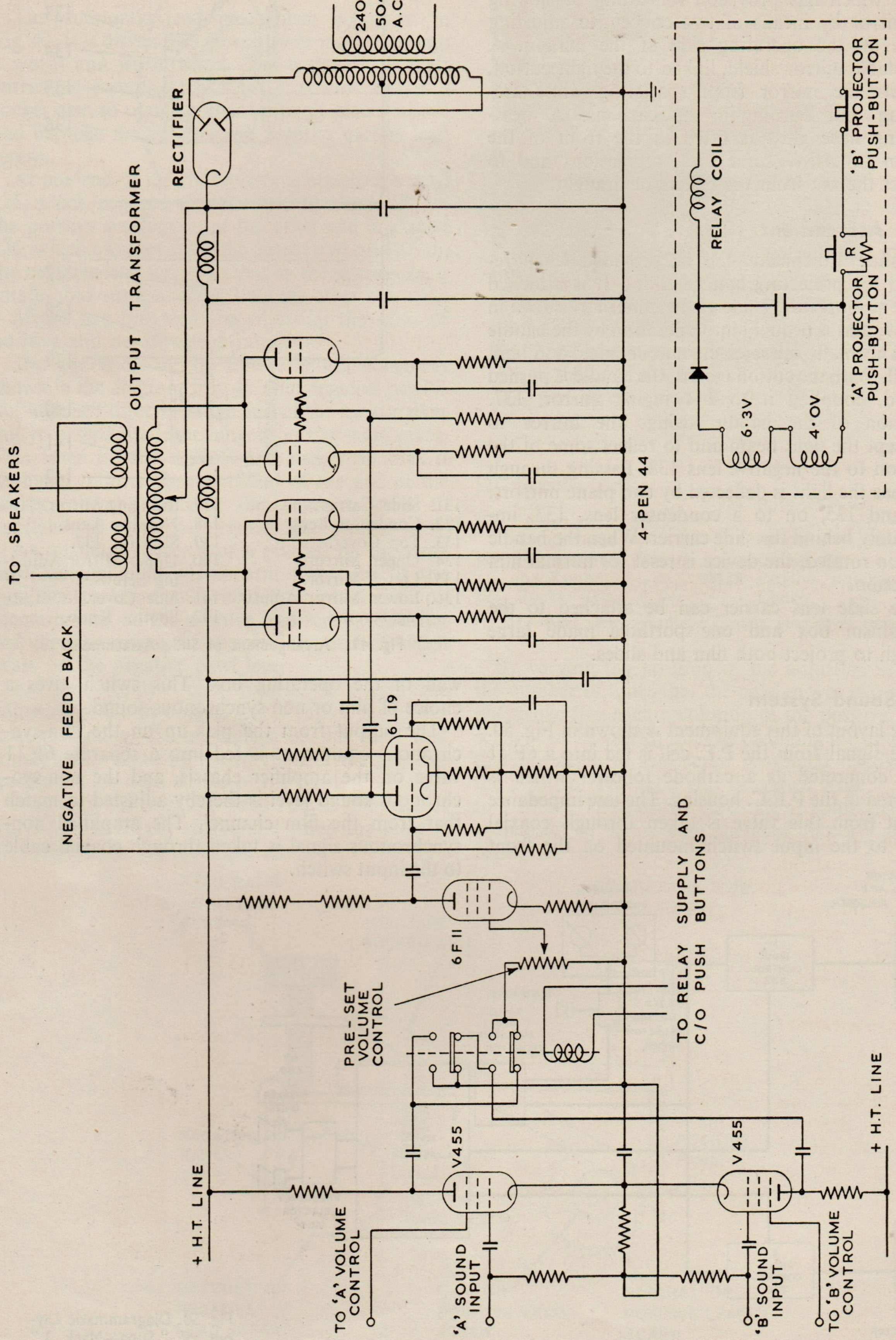


Fig. 51. Simplified Diagram of "Supa—Mark 2" Amplifier Circuit, and, inside dotted enclosure, connections for projector changeover.

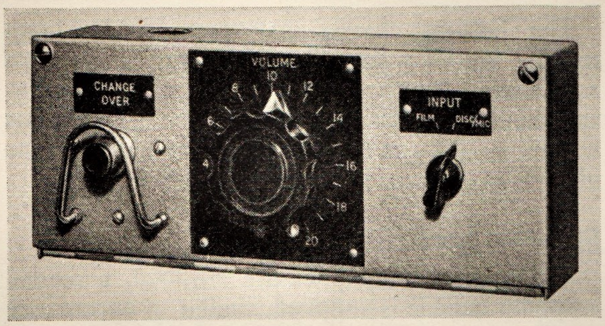


Fig. 52. Input switch box.

The Amplifier

A simplified diagram of the amplifier is shown in Fig. 51.

The signals from each of the input switches are taken through separate first-stage valves, V 455, and the contacts of a small relay to a common second-stage valve, Type 6F 11. When the relay is de-energized, the " A " soundhead channel is earthed and the sound on " B " channel is passed to the power amplifier stages. When the relay is energized, the " B " channel is earthed and the sound on " A " channel is connected to the power amplifier. The power amplifier stages are designed in a similar manner to those in the S/U/P/A amplifier, a push-pull output stage being obtained without the use of transformers. There are four Pen 44 valves operating in parallel push-pull in the final output stage. A preset volume control is inserted in the control grid of the second-stage valve.

Negative feedback is introduced by a connection from the output transformer secondary winding through a potential divider into the cathode of the phase splitter valve, Type 6L 19. The output is designed to feed into a 500-ohm load. The main rectifier is of the orthodox full-wave type, with capacity input filter.

The 10·5 volt supply for operating the changeover relay is obtained by connecting the 6·3 volt and 4 volt filament windings in series ; the supply is then rectified by a half-wave metal rectifier located in the amplifier chassis.

Input Switches

One of these units, of which there are two, is illustrated in Fig. 52. They are mounted on the front wall of the projection room, convenient to each projector. Each box contains a volume control, a Film/Disc selector switch, and a changeover push-button. This push-button controls the relay described in the foregoing section, and its action may be summarized by saying that, when push-button A is pressed, the changeover relay coil is energized, and the " A " projector sound channel is connected to the output stages ; while pressing push-button " B " de-energizes the relay coil, disconnects " A " projector sound channel, and connects " B " to the output stages.

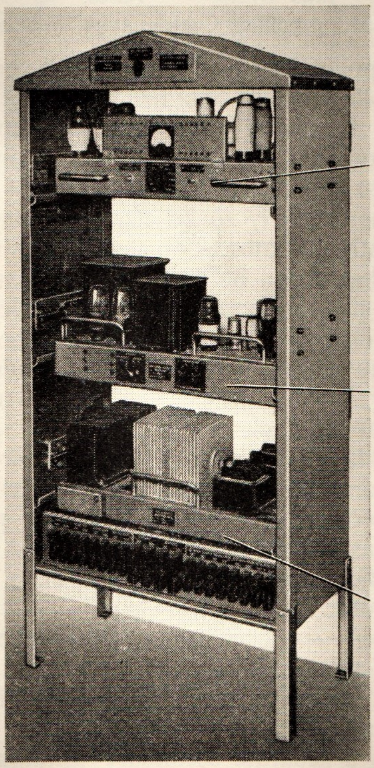
The connections of the push-button switch and relay coil are shown in Fig. 51. It should be noted that, while resistor R is of such an ohmic value that it will pass enough current to hold in the relay once the latter has closed, the current is insufficient to close the relay. When fully-electrical changeover is provided, pressing the button also operates the changeover shutters of the projectors.

The volume control is a potentiometer which varies the bias on the suppressor grid of the first amplifier valve V 455, of which there are two, one for each soundhead. The " Film/Disc " switch provides selection from either projector. Whichever switch is put into the " Disc " position will cause non-sync. sound to be connected to the amplifier when the push-button on that particular box is pressed.

Amplifier Cabinet

The cabinet illustrated in Fig. 53 is arranged for wall or floor mounting. The terminal board to which all incoming and outgoing cables are connected is at the bottom of the cubicle. All sub-circuit fuses are grouped on one panel, also at the bottom of the cubicle. At the top is a selector switch for microphone or non-sync. reproduction.

The cabinet contains three separate chassis, the top one being the amplifier chassis. The small panel carrying the meter and the components for frequency-range adjustment is hinged to facilitate servicing ; the meter selector-switch is mounted on the front edge of the chassis below the panel.

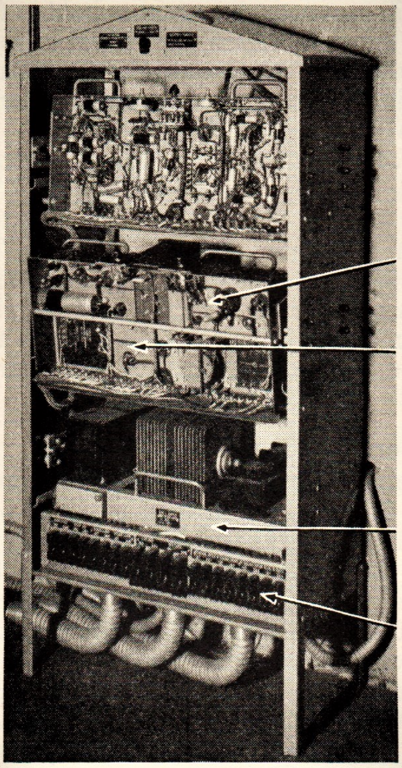


151
152
153

151. Main Amplifier.
152. Amplifier Rectifier and Deaf-Aid Amplifier.
153. Exciter Lamp Supply Unit.

Fig. 53. Amplifier Cubicle, cover removed.

"Supa—Mark 2" PROJECTOR (cont'd.)



156. Deaf-Aid Amplifier.
157. Amplifier Rectifier Unit.
158. Supply Unit.
159. Sub-circuit Fuses.

Fig. 54. Amplifier Cubicle, trays inverted.

H.T. supplies for the P.E. cell and the P.E.C. cathode followers are obtained from this chassis. A P.E.C. balancing potentiometer network is provided for adjusting the excitation of one of the P.E. cells to balance their output.

Components likely to be affected by vibration are resiliently-mounted. The chassis is fitted with slides so that it can be drawn forward and tilted upward to give easy access to the underside. Fig. 54 shows the chassis in this position with the bottom covers removed. All connections are made to the chassis by flexible leads terminating in spade terminals at the back of the chassis.

The middle chassis carries the amplifier rectifier unit (including power output transformer) and the output selector-switch which has four positions connected as follows :—

1. Artificial load, no sound output.
2. Monitor only.
3. Screen speakers, monitor speakers, and deaf-aid amplifier.
4. P.A. speakers, monitor speaker, and deaf-aid amplifier.

There is a separate secondary winding on the output transformer, loaded by a preset attenuator to feed the monitor speaker.

Space is available on this chassis for a deaf-aid single-valve amplifier suitable for 30 headphones, if required.

The bottom chassis carries the exciter-lamp rectifier units for two 10-volt, 5-amp. lamps, also A.C. supply for the framing and intermittent inspection-lamps. This tray slides forward but does not tilt as it is not necessary to have access to the underside of the tray for normal servicing.

Standby Amplifiers

When standby facilities are required, a second amplifier cubicle is supplied, similar in appearance to the main one, except that in the position normally occupied by the exciter lamp supply unit, a change-over switch panel is fitted.

Speaker Arrangement

A dual-channel speaker system is used. A 500-ohm line runs from the amplifier output transformer to a frequency-selector unit at the screen. This unit divides the output into two frequency bands, 0 to 500 cycles and 500 cycles upwards, the arrangement being similar to that of the S/U/P/A equipment.

The standard speakers consist of two L.F. Units mounted on a short horn, and one H.F. Unit on a multi-cellular exponential horn. A typical speaker installation is shown in Fig. 55. Alternatively, depending on the size and acoustics of the auditorium, a speaker combination similar to that already described for S/U/P/A equipments may be used.

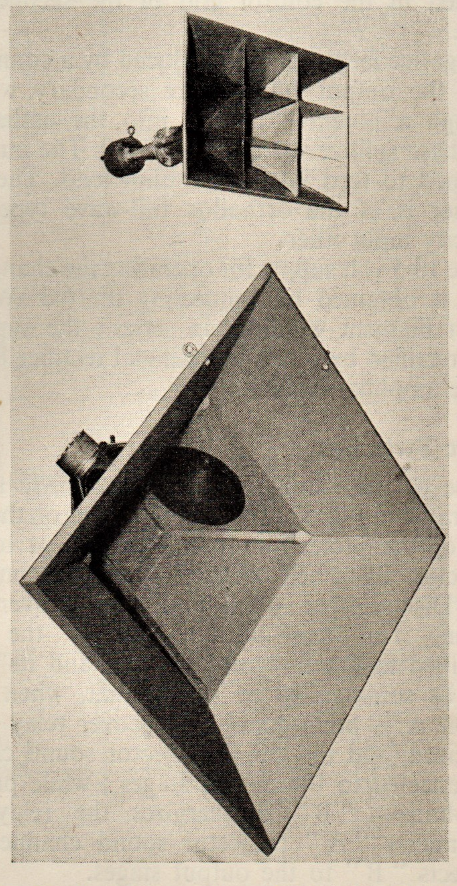


Fig. 55. Typical "Supa—Mark 2" speaker installation.

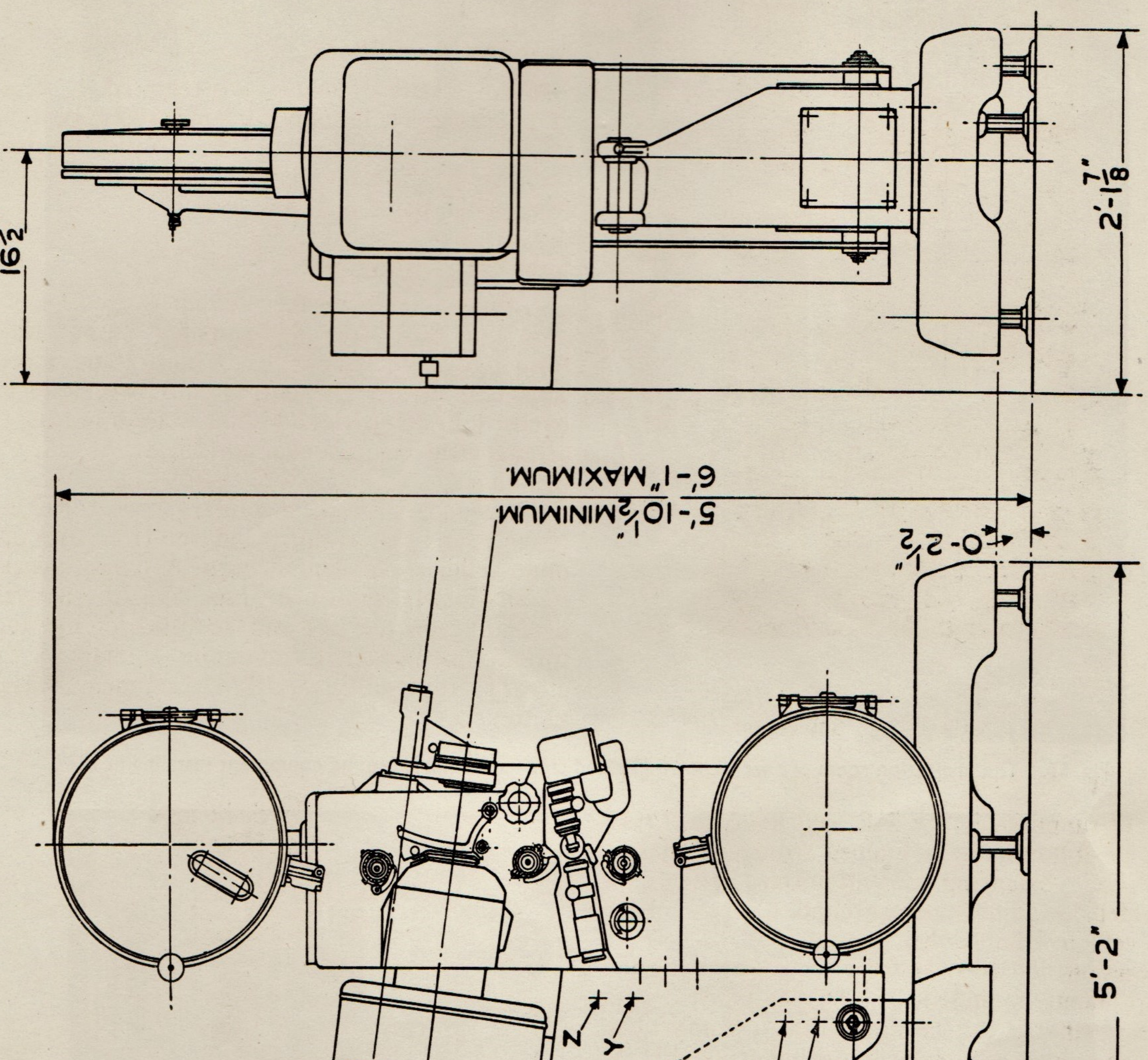


Fig. 56. Dimensioned outline of "Supa—Mark 2" Projector. The letters A, B, C, Y, and Z indicate alternative positions for pivot pins and anchor-bolts.

THE OLD AND THE NEW

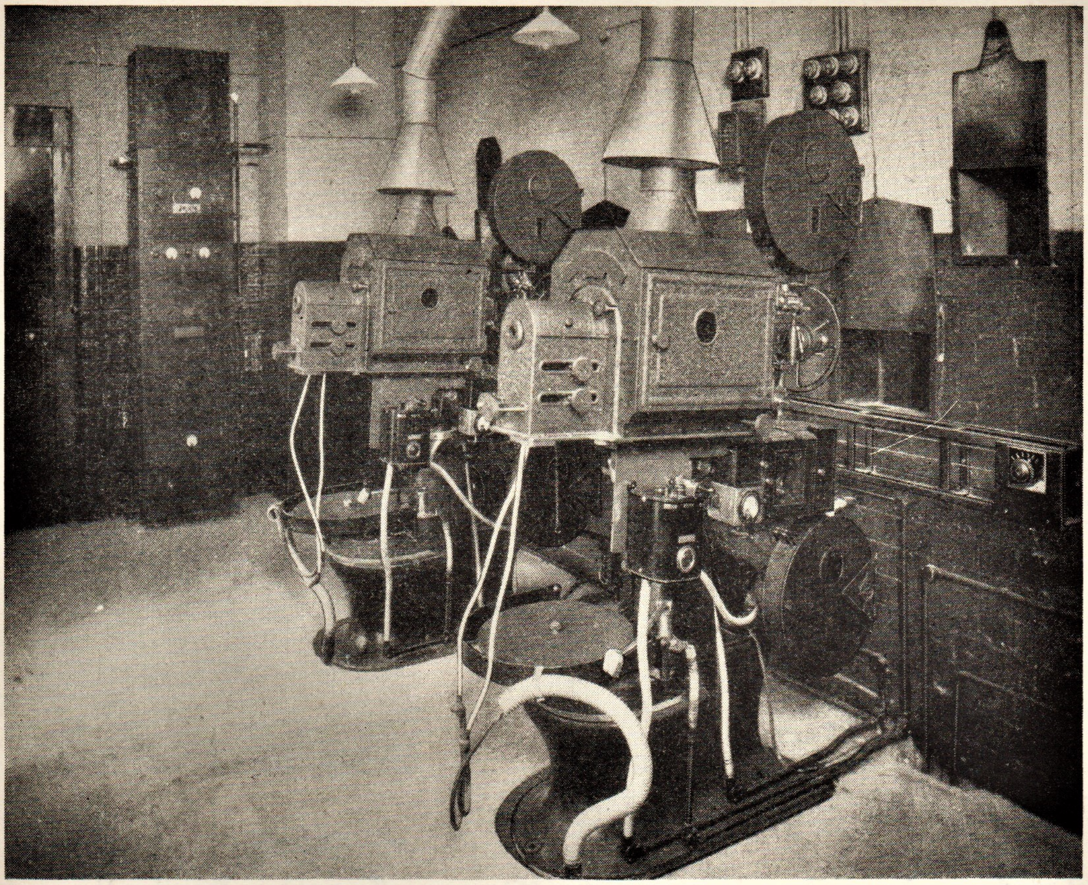


Fig. 57. The projection room of a well-known Midland cinema, with BTH sound equipment installed in 1929.

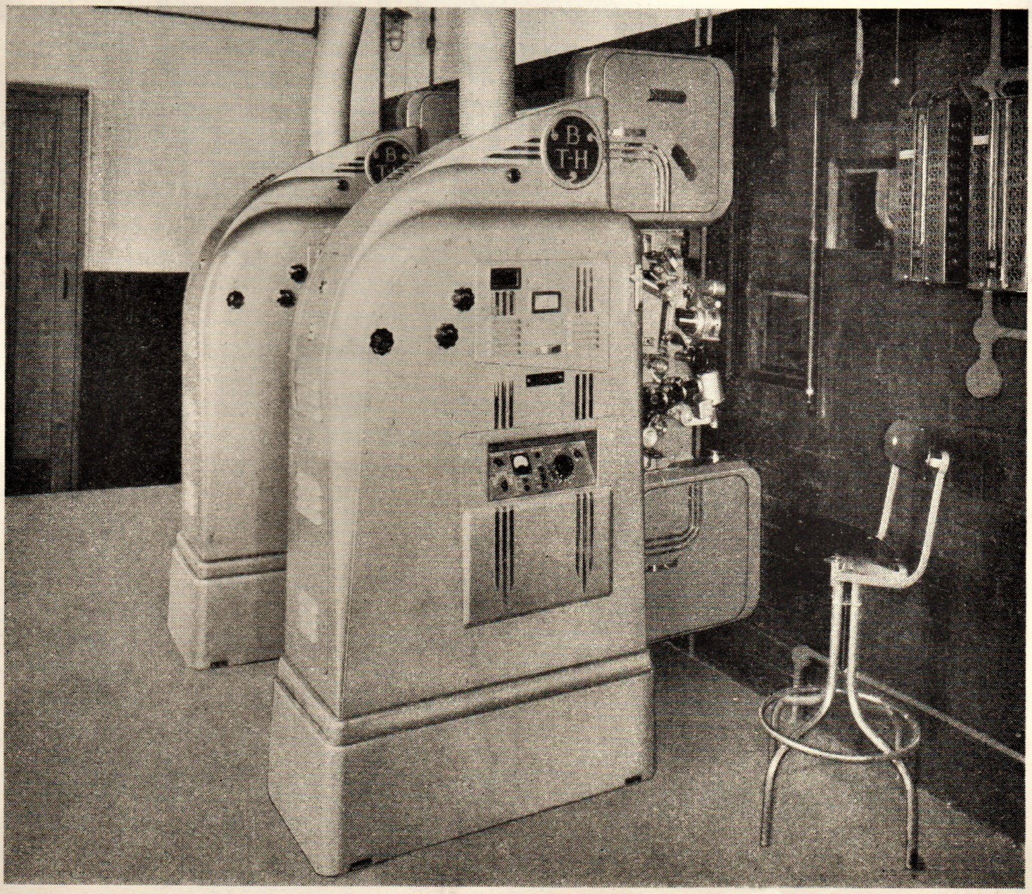


Fig. 58. The same projection room today, with S/U/P/A.

Printed in England by Albert Frost & Sons, Ltd., Rugby, for BTH.