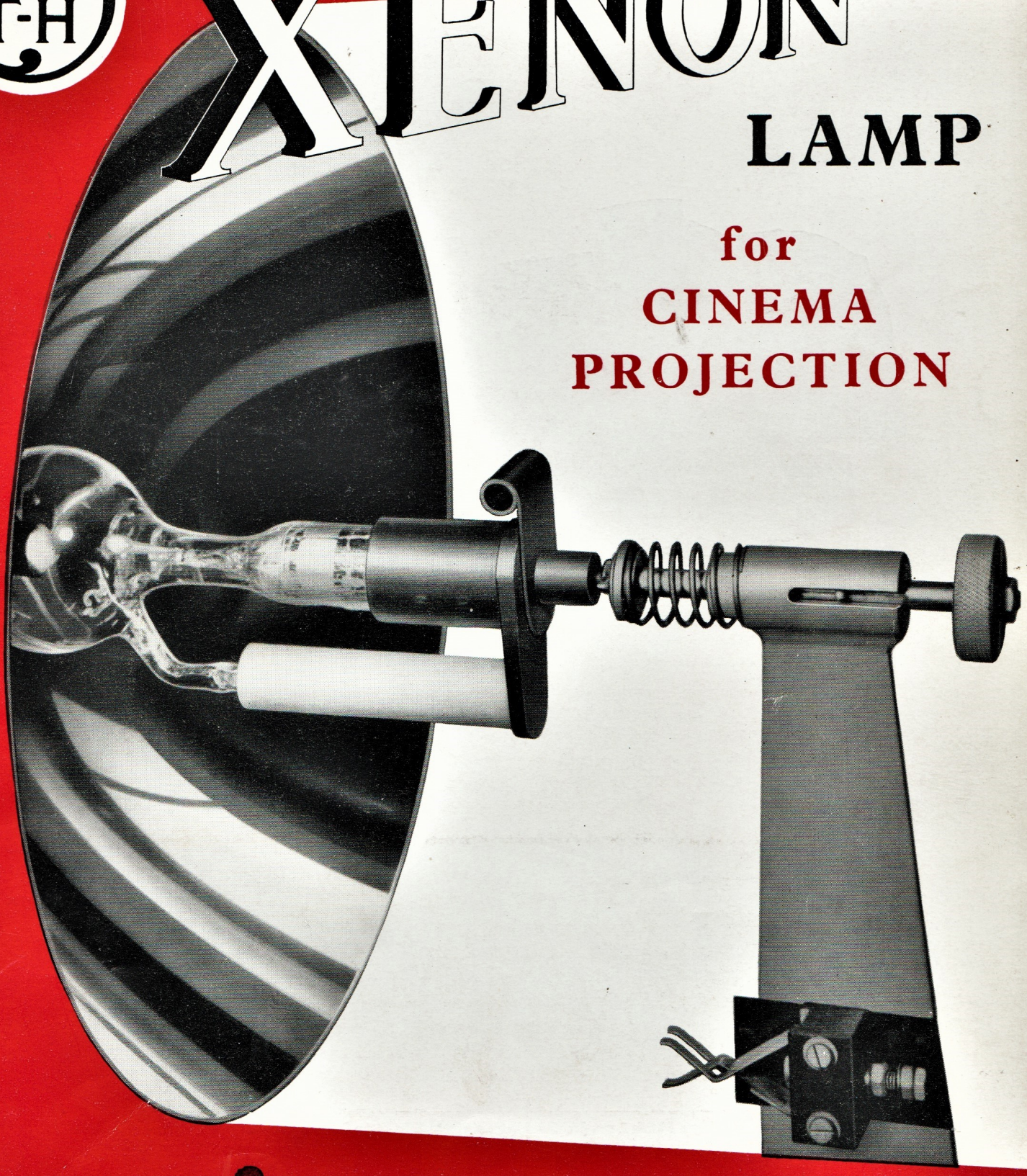
Descriptive List No. 7484-2

B T-H

XENON LAMP

for CINEMA PROJECTION



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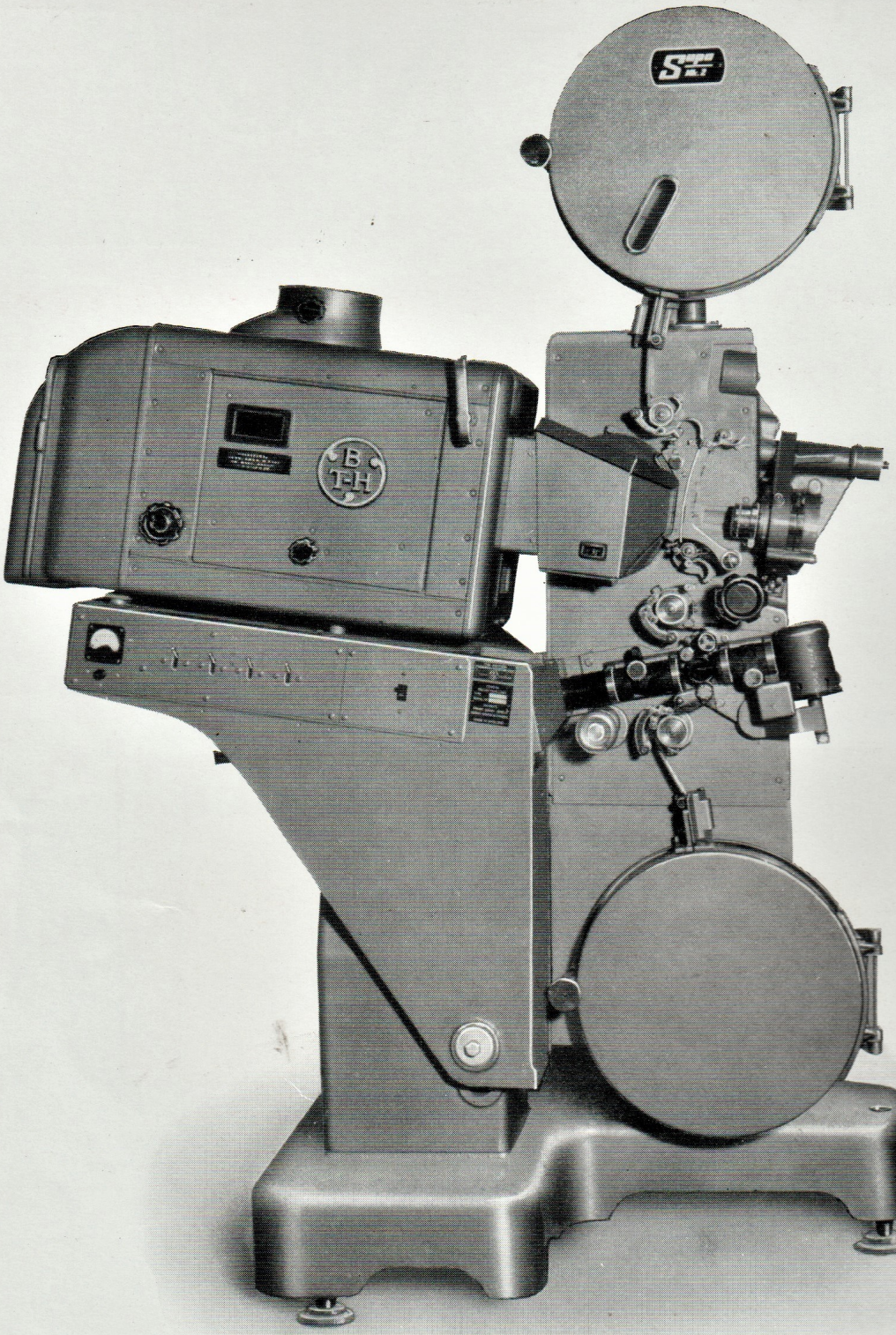

Fig. 1. BTH Supa Mark 2 projection equipment, with Type LX xenon-lamp lantern.

THE XENON LAMP FOR CINEMA PROJECTION

An efficient and economical alternative to the carbon-arc

The introduction of the xenon lamp for projection purposes is a milestone in cinema history. Starting is by pushbutton; the brilliant light on the screen requires no projection-room attention to keep it steady; and maintenance worries almost completely disappear. Thus it makes an important advance towards 'automation' in the cinema, while among its advantages is its long guaranteed life.

BTH Sound Equipment Limited has been incorporated into the Electronic Apparatus Division of Associated Electrical Industries. The correct name and address is now :—

Associated Electrical Industries Limited,
Electronic Apparatus Division,
Sound Equipment Group,
Crown House, Aldwych, London, W.C.2

As efforts are made constantly to improve both designs and methods of manufacture, the apparatus supplied may differ in details from the illustrations.

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Edition B.
*Cancels Edition A.

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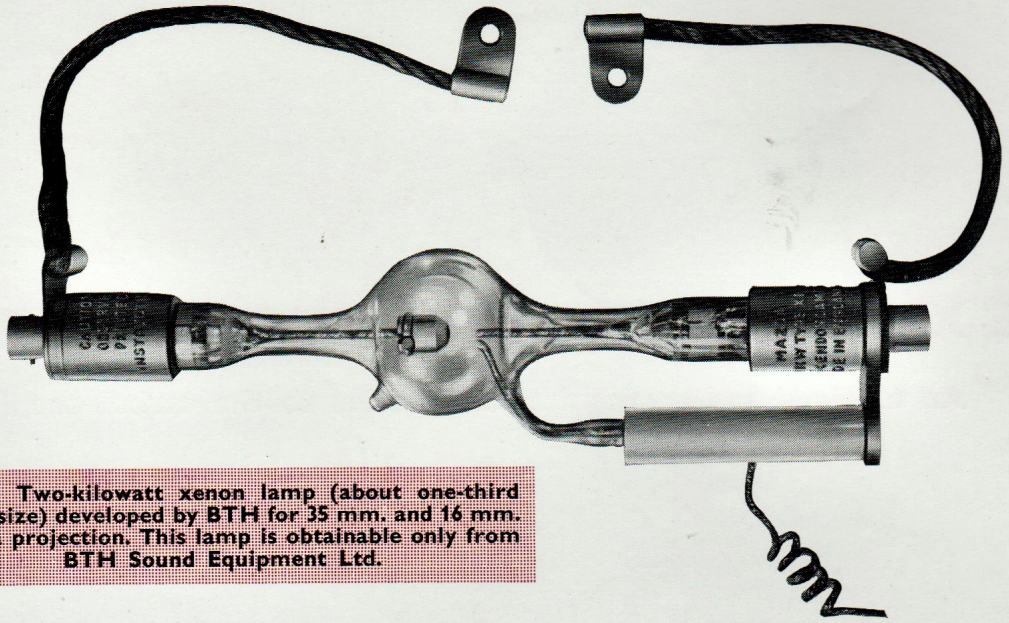

Fig. 2. Two-kilowatt xenon lamp (about one-third actual size) developed by BTH for 35 mm. and 16 mm. cinema projection. This lamp is obtainable only from BTH Sound Equipment Ltd.

THE XENON LAMP—ITS DEVELOPMENT AND ADVANTAGES

THERE HAVE BEEN many attempts to replace the carbon arc in the cinema projector lantern by some form of bulb-enclosed lamp or by 'cold light', as it is popularly (though incorrectly) called. Until recently, these substitutes have proved unsatisfactory, by reason of insufficient light output, poor colour-rendering, undue delay in reaching operating brilliance, or a combination of these shortcomings. But now at last a xenon-discharge lamp is available that does provide a completely satisfactory alternative; a brief review of the development of this lamp may be of interest.

The xenon arc-discharge lamp has been known in laboratories for many years; it was first used commercially in stroboscopic or 'flash' tubes, or for ordinary 'flashlight' photography—applications that are, incidentally, still in general use. The next application was for studio floodlighting, to replace the carbon-arc 'floods', as the colour of the xenon discharge is very suitable for photography; a lamp with a relatively-low internal pressure, operating at a low voltage, was developed by BTH engineers for this purpose. The advantages of instantaneous light output and good colour rendering made the xenon lamp seem very promising for film-projection, and a great deal of development work on these lines was carried out in England, Germany, and America.

For film projection, a compact light-source is essential, so that a high-efficiency optical system can be used to project the light through the small 'picture frames' on the film; it was thought at one time that the most efficient way to use the lamp would be to 'pulse' the current so that the light was only produced when it was actually wanted—i.e. when the film was stationary in the gate and not covered by the flicker shutter—as this would enable at least double the light output to be obtained for the same power input as used for continuous operation. BTH engineers demonstrated pulsed-light operation on 16-mm. projector equipment at the 1950 Faraday Lecture.

It was soon apparent, however, that, while there was no great difficulty in the manufacture of apparatus to provide pulses synchronous with the movement of the film, the system was seriously handicapped by the short life, for pulsed or A.C. operation, of the compact-source xenon lamps then available. For this reason, BTH, pioneers in this field, turned their attention to research into D.C. operation of compact-source projector lamps.

The xenon arc discharge, in the compact form required for film projection, is essentially a high-current low-voltage arc, and the earlier forms developed for studio lighting operated at roughly twice the current of a carbon arc of equivalent light output; but considerable research has resulted in the development of xenon lamps of higher voltage and lower current. The light output of the Mazda Type XE/U/27 xenon projection lamp is remarkably high, particularly in view of its comparatively small power input, and the three-electrode design enables this result to be obtained at about half the internal gas-pressure of Continental lamps at present available.

The light from the xenon lamp does not, as with the carbon arc, come from a crater in the positive electrode, but from a 'cathode spot' near the negative electrode; the shape and size of the main light-emitting portion is completely unlike that of a carbon arc. For this reason, the best results cannot be obtained by the adaptation of existing carbon-arc mirrors, as in the case of some Continental examples; the optical system must be completely re-designed, a point which has been observed in the development of the BTH Type LX projector lantern. This lantern is described in detail on a later page, but it may be here emphasized that the BTH design gives, with a single mirror, an acceptable light-distribution on the screen of considerably more total light than is obtainable from the double-mirror-and-lens designs. This is due in part to the ability of the Mazda lamp to operate in a horizontal position, whereas the two-electrode lamps can only burn vertically and thus cannot use the most efficient optical system.

One of the many advantages of the xenon projection lamp is that, being pushbutton controlled and requiring no adjustments or attention throughout its long life, it makes a positive contribution towards 'automation' in the projection room.

Future Developments

The Mazda Type XE/U/27 xenon lamp here described is rated at 2 kW, and for 35 mm. projection gives a light output in the range 4000/6000 lumens, suitable for medium-size cinemas and Cinemascope screens up to about 37 ft. wide. At the time of writing, BTH engineers are working on the development of a xenon lamp, projector lantern, and high-efficiency power supplies to give a much higher light output, suitable for the larger cinemas and screens.

Some advantages of the xenon lamp

Simple and instantaneous starting	pushbutton control and no 'warming-up' period.
Completely steady light on screen	constant and independent of the operator.
Light suitable for all films ..	similar in colour to sunlight. No change in colour with change of operating current.
Simplicity of operation	once initially focused, no further adjustments are required.
Negligible maintenance	no dust-laden fumes or carbon spatter, no moving parts, no continual re-conditioning or replacement of mirrors.

Fig. 3. The lamp in its protective covering bag as supplied.

THE MAZDA XENON LAMP

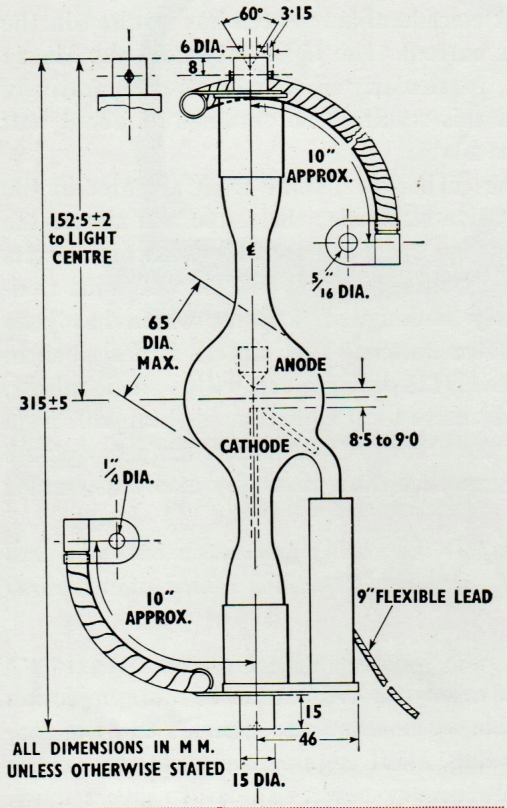

Fig. 4. Outline and principal dimensions.

Technical details of the characteristics and performance of the Mazda xenon lamp are given on Page 6. The general appearance of the lamp is shown in Fig. 2. The electrodes are mounted in a fused-silica envelope, of good optical quality and spherical in shape to obtain the greatest mechanical strength.

The conductors pass into the envelope through robust molybdenum-foil seal assemblies, which are capped to provide between-centre mounting, with electrical connection through flexible copper leads. These design features prevent undue stresses being transmitted to the lamp body, and the construction ensures that the arc is located on the centre-line of the lamp.

In addition to the massive tungsten anode and a relatively-small split cathode to support the main arc current, there is an auxiliary probe which not only greatly reduces the impulse voltage necessary for arc-ignition but also enables a stable arc to be initiated with the lamp at any angle to the vertical. The initial arc is struck between the probe and the cathode at a current of about 20 amperes, and this arc ionizes the space between the anode and cathode, so that the main arc strikes almost instantly after the auxiliary arc; in BTH lanterns, a relay in the control system disconnects the probe immediately the main arc has struck.

The lamp is filled with xenon gas at a pressure of about four atmospheres, and the pressure increases by a factor of about $2\frac{1}{2}$ when the lamp is hot. For this reason, it must always be operated in an enclosed lamphouse, and arrangements must be made, as detailed later, for the power supply to the lamp to be cut off when the lamphouse door is opened. When handling or changing the lamp, it should always be kept in its canvas covering, shown in Fig. 3, which serves the secondary purpose of keeping the bulb clean; the natural oils of the fingers, unless removed before operation, may impair the transparency of the fused-silica envelope.

Advantages of the Mazda three-electrode construction

(1) Low ignition voltage—about one-eighth of that required for a two-electrode lamp.
(2) Negligible interference with sound systems on striking. In some two-electrode lamps, the interference is so great that users are recommended to switch them on before the show.
(3) Ability to run the lamp at any angle from the vertical. Two-electrode lamps can only run vertically, making it impossible to use the most efficient form of optical system.
(4) No choke required in main supply lead for the impulse ignition.

Guaranteed Life and Recommendations

The Type XE/U/27 lamp is guaranteed in the British Isles for a life of 1000 hours, on the basis of free replacement for failure in less than 250 hours of operation, and replacement at *pro rata* cost between 250 and 1000 hours. This guarantee applies only to lamps used in approved equipment at

not more than the full rating of 80 amperes, and on power supplies with not more than 5% r.m.s. current-ripple.

The eventual failure of the xenon lamp is normally due to internal blackening of the bulb, the light output being thus progressively reduced. For the purposes of the guarantee, the life is regarded as ending when the light falls to 70% of its initial value.

When, as in film projection, a reasonably constant light output over the working life of the lamp is required, it is recommended that the lamp should initially be under-run, and that at subsequent periods the current should be increased in 5-ampere steps to the maximum rating of 80 amperes. This will generally mean running a new lamp at about 70 amperes. Under-running the lamp will lengthen its effective life, and, since the arc is enclosed, no mirror-spattering will occur, as might be expected with carbon arcs.

Lamp Starting

The D.C. supply is connected through the starter unit to the probe. The starter circuit, when energized from standard 200/250-volt, 50/60-cycle A.C. supplies, provides a pulse voltage of about 5000 volts to initiate the auxiliary discharge between the probe and the cathode. This arc in turn initiates the main arc between the cathode and the anode.

In the horizontal position a probe current of 20 amperes is required, momentarily; this must be switched off immediately the main arc has struck. The basic starting circuit, for resistance ballast, is shown in Fig. 5.

Power Supplies

For all but small screens for either 35 mm. or 16 mm. film-projection, the xenon lamp will be required to run at its maximum rating of 80 amperes as it nears the end of its useful life, so the power supply must be capable of providing at least 80 amperes per arc. In order to match approximately the light outputs of an old and a new lamp, and so to keep an approximately uniform light on the screen, it will be necessary to be able to adjust the supply to give 70 and 75 amperes, as well as the full rating of 80 amperes.

For cinema use, if the existing supply medium is a choke-controlled rectifier of rating up to 80 amperes per arc, it will in general be suitable for the supply to a xenon lamp, without any change except, perhaps, a slight adjustment to the choke air-gap, and possibly some additional smoothing. With such a rectifier, the cost of power supply to the xenon lamp will be proportional to the arc wattage, and will thus be a little cheaper than for a carbon-arc, to give equal light on the screen.

Where the existing power-supply system is of high voltage, with resistance ballast, the installation of a reactance-controlled rectifier specially designed for xenon-lamp operation will usually justify itself in a comparatively short time by the saving in power costs due to increased efficiency.

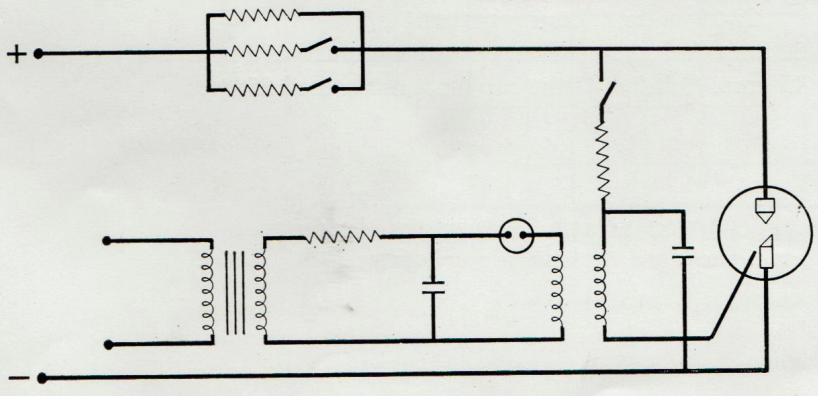

Fig. 5. Basic starting circuit for xenon projection lamp, using resistance ballast system.

Existing single-phase rectifiers will require additional smoothing to reduce ripple, but equipments specially designed for use with the Mazda xenon lamp are now available; they have an overall efficiency, mains to lamp, of 83%, with adequate smoothing to give less than 5% r.m.s. ripple.

Interlocks

On BTH equipments using the xenon lamp, safety interlocks are provided on the lamphouse to cut off the supply to the lamp if the doors are opened. These interlocks consist of microswitches which complete the coil circuits of the A.C. contactors that connect the reactance-controlled rectifiers to the mains supply, and the A.C. for energizing the striking circuit is taken from the rectifier side of the contactors. Thus, when the doors are open, neither the D.C. supply nor the A.C. striking supply is connected to the lantern.

For resistance-ballast controlled supplies, contactors are required in the D.C. circuit to perform the same functions.

TECHNICAL DATA

Type .. .. .. Mazda XE/U/27

Rating

Watts	2 kW
Supply volts	50 volts D.C. (minimum, open circuit)

Physical Characteristics (see Fig. 4).

Caps: At each end, a special cap with a conical centre hole for mounting, and a flexible lead.

Dimensions (in mm.):

Diameter of bulb ..	65·0 (max.)
Overall length (incl. caps)	315·0 ± 5·0
Length to light centre from end of 'anode' cap	152·5 ± 2·0

Electrical Characteristics

Lamp rating	2000 watts (nominal)
	1000 watts (minimum)
Supply voltage..	35 volts D.C. (minimum)
Arc voltage	27-29 volts
Lamp operating current ..	80 amp. (max.)
	45 amp. (min.)

Light Source Characteristics and Performance

Source size (in mm.)	Arc width—4·0 (approx.) Arc length—8·5—9·0
Mean horizontal candle-power	7800 candelas.
Lumens/watt	35 (approx.)
Polar curves of candle-power ..	Fig. 6
Brightness distribution	Fig. 7
Spectral distribution	Fig. 8

Average Life

1000 hours at normal rating from ripple-free D.C. supply. At lower lamp-loadings, life is increased. For approved film-projection equipment, life is guaranteed up to 1000 hours (see above).

Operating Position

Lamp will operate in any position; when vertical, anode should be uppermost. In any other position, the probe must be located below the arc-gap.

Temperature

Temperature measured at a point halfway along the cap must not exceed 250°C.

The Mazda Type XE/U/27 projection lamp has been specially designed for BTH Sound Equipment Limited, and is obtainable only from this Company.

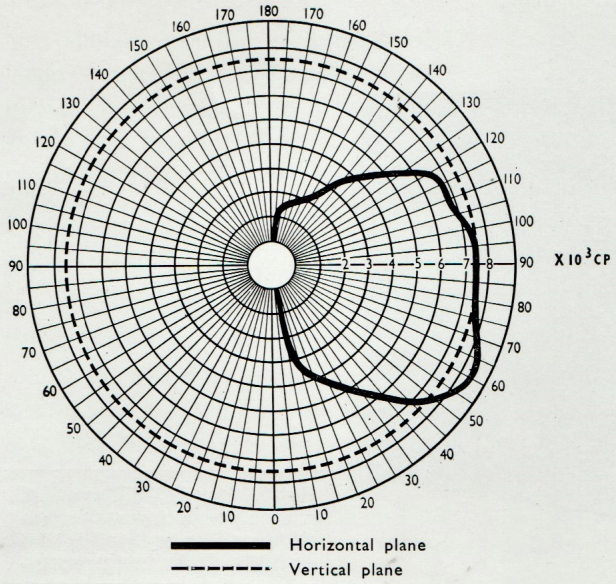

Fig. 6. Polar curves of candle-power for typical Mazda XE projection lamp.

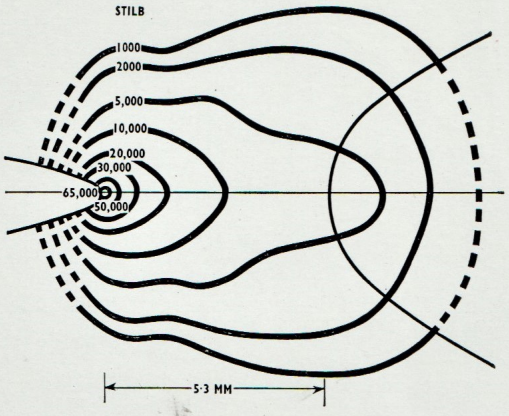

Fig. 7. Brightness distribution for similar lamp with 5·3 mm. arc gap.

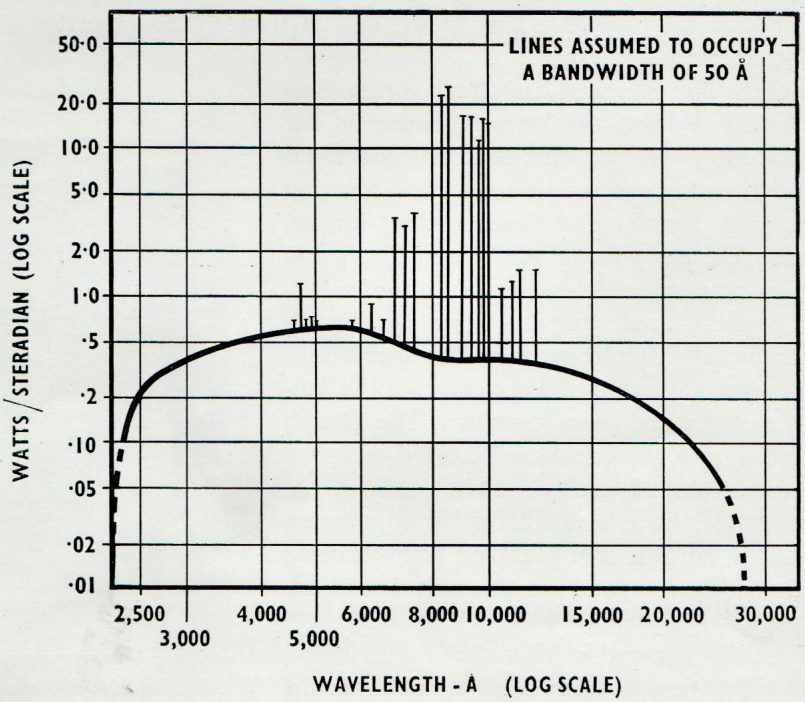

Fig. 8. Spectral distribution of light from xenon projection lamp.

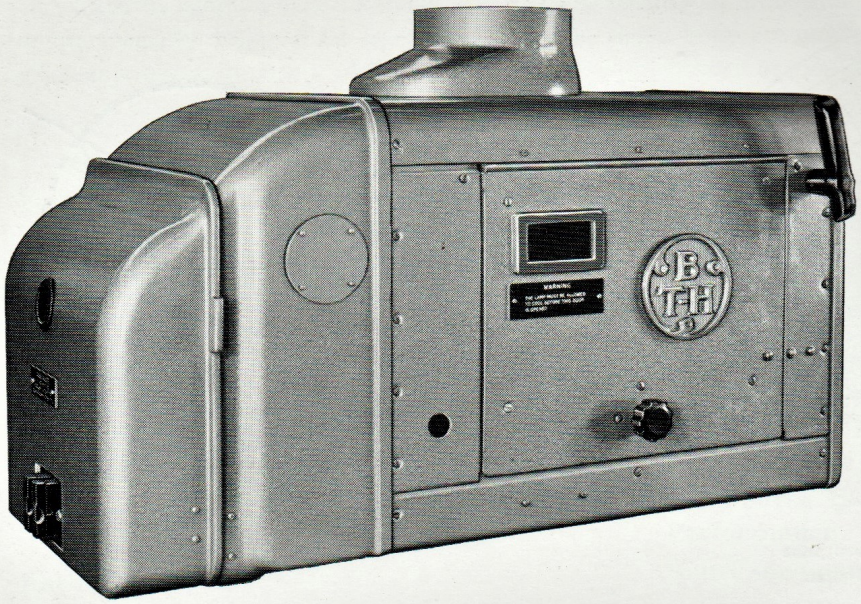

Fig. 9. The BTH Type LX projector lantern—designed to utilize to the full the benefits of the xenon lamp.

BTH XENON-LAMP PROJECTOR LANTERN

The BTH projector lantern, Type LX, has been specially designed to exploit the benefits of the Mazda xenon lamp for 35 mm. film-projection. In its design, the maximum usable light collection is ensured by means of a single deep mirror, which takes full advantage of the ability of the Mazda lamp to operate in a horizontal position. The system employed, with the lamp located on the horizontal axis, gives an inherently-symmetrical light distribution; the mirror shape is such as to improve substantially, with a standard projection lens, on the British Standard Specification of 60% minimum ratio of side-to-centre screen luminance.

Each end-cap of the Mazda xenon lamp has a conical hole on the optical axis (Fig. 4), and the lamp mounting in the lantern consists of conical-ended spindles, the front one under spring pressure and the rear one screwed, for final focusing when installing the lamp. By virtue of these centring devices, the lamp is accurately aligned with the mirror and the optical axis. The two spindles are removable so that, when the lantern is first installed, an 8 mm.-diameter rod can be inserted for the optical axis to be accurately aligned with the film aperture.

Fig. 9 shows the general external appearance of the lantern, and Fig. 11 the mirror and lamp mounting. The 12-inch diameter mirror is of silvered glass, and can be tilted or slewed by means of concentric slotted controls at the side of the lantern. Once these controls have been set, further adjustment is unnecessary until the lamp is changed. The lamp-focusing adjustment is friction-controlled, and remains locked after adjustment.

The chassis is readily removable from the lantern body; provision is made for the incorporation of an ammeter on the lantern, if one is not already available elsewhere in the D.C. supply.

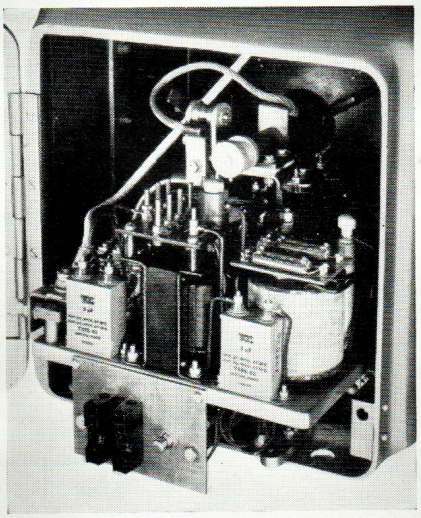

Fig. 10. Striking mechanism, safety cover removed, showing ease of access.

Arc-striking Equipment

The arc-striking equipment, the basic electrical circuit of which is shown in Fig. 5, is mounted on a baseboard inside the lantern body. The 'start' pushbutton and the A.C. mains fuses are at the rear, and accessible from the outside; inside are the small mains-transformer, the enclosed spark-gap, the charging condenser, and the pulse coil, together with the associated relays.

A view of the striking mechanism is shown in Fig. 10. To start the lamp, it is only necessary to close the main arc contactor and press the 'start' button; the striking sequence is then automatic, and the striking circuit automatically disconnects itself immediately the main arc strikes.

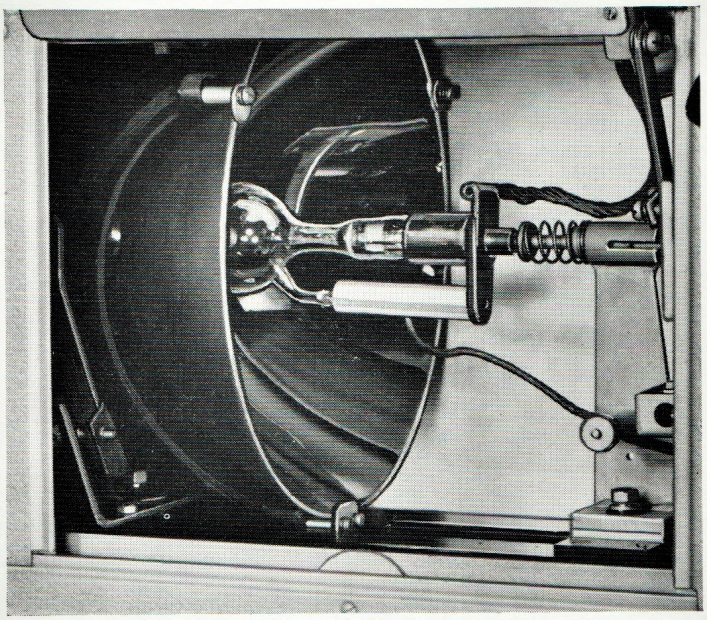

Fig. 11. Inside the lantern. Note the deep mirror and the simplicity of the layout.

If a lamp fails to strike first time—as it may near the end of its life—it will almost invariably strike if the 'start' button is pressed again within about five seconds, i.e. while the cathode is hot from the auxiliary arc. On the BTH lantern, a relay circuit is incorporated which automatically performs this 'restrike' action after a short delay, independent of the operator.

Slide-projection

If required, a slide-projection attachment can be fitted. Part of the light from the xenon lamp is deflected, by means of an auxiliary mirror, through the slide attachment. For normal film-projection, the auxiliary mirror is moved clear of the main projection beam.

Maintenance

The only maintenance normally required is the periodical dusting of the mirror—once a week will usually suffice. There are no dust-laden fumes or hot copper to damage or discolour the mirror, as with a carbon arc, and no continuously-moving parts to require attention. The fairly-frequent resilvering or replacement of the mirror, which is general with carbon arcs, is unnecessary with the xenon lamp.

Screen Sizes

The size of screen that can be adequately illuminated by the LX lantern depends on the following factors: (a) screen 'gain' or reflectivity; (b) transmission factor of lenses in use; (c) type of aperture—cinemascope, 'wide-screen', or standard 'four-by-three'; (d) lamp current.

The British Standard Specification for screen luminance requires between 8 and 16 foot-lamberts at the centre of the screen. Taking a mean of these values at 12 foot-lamberts, and screen gains of 0·8 and 1·5 for, respectively, matt-white and wide-angle 'silver' screens, the table overleaf shows the screen widths for which the LX lantern is suitable. Many reflecting (silver) screens have a gain far in excess of 1·5, and with such surfaces the lantern will adequately fill screens considerably wider than those shown in the table.

Table of screen sizes for use with the LX Lantern

Lamp Current (*Amperes*)	Silver Screen (Gain = 1·5)		Matt-white Screen (Gain = 0·8)	
	Cinemascope	Wide Screen	Cinemascope	Wide Screen
80	42 ft.	33 ft.	30 ft.	24 ft.
75	39 ft.	31 ft.	28·5 ft.	23 ft.
70	37 ft.	29 ft.	27 ft.	21·5 ft.
65	34 ft.	27 ft.	25 ft.	20 ft.
60	31 ft.	25 ft.	23 ft.	18·5 ft.
55	27·5 ft.	22 ft.	20 ft.	16 ft.
50	24 ft.	19 ft.	18 ft.	14·5 ft.

Technical Data

Lamp	Mazda XE/U/27 (50-80 amp.)
Aperture value	f 1·85
Mirror Diameter	12 inches (305 mm.)
Minor focus (arc to mirror)	2·5 inches (63 mm.)
Major focus (mirror to gate)	26·5 inches (670 mm.)

Shipping Specification (approximate weights)

Net Weight ..	142 lb. (64·5 kg.)
Gross Weight	364 lb. (165 kg.)
Ocean Tons ..	0·8 (0·9 cu. m.)

Principal Dimensions

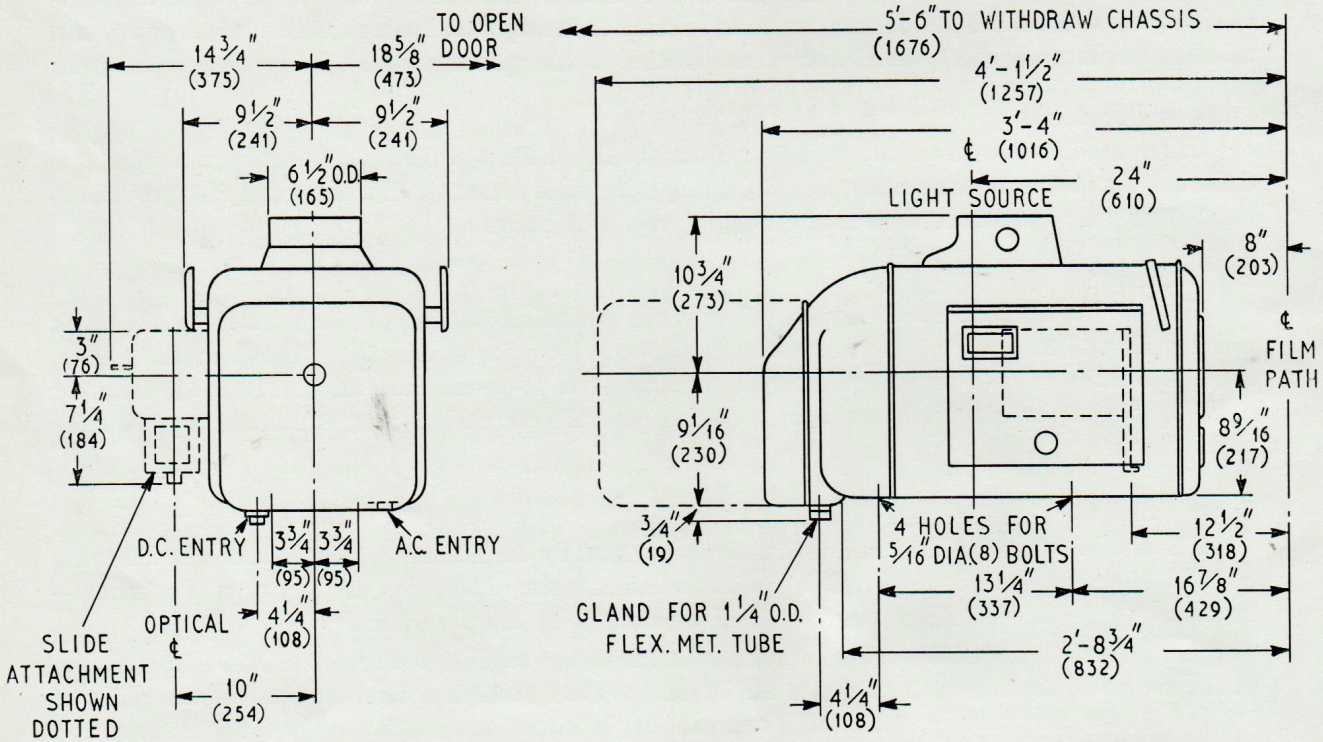

Fig. 12. Principal dimensions of the LX Lantern (millimetre equivalents in brackets).

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

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