MOTION PICTURE PRESENTATION MANUAL

The British Kinematograph, Sound and Television Society

MOTION PICTURE PRESENTATION MANUAL

A comprehensive handbook of projection practice

FOREWORD

The Box Office success of the highly complex skills and vast financial outlay involved in modern film production depends finally on one man – the Projectionist.

This new edition of the B.K.S.T.S. Film Presentation Manual has been thoroughly revised under the supervision of the Technical Advisory Committee of the British Kinematograph, Sound and Television Society. We have concentrated on the practical work of the projectionist under the following main headings:

The Care of Film
Projection Equipment and its Use
The Screen
Power Supplies and General Services
The Presentation of 16mm Films

Some projectionists may be making the change from ordinary methods of projection to multiple operation using long-playing and automated equipment. They will find an introduction to these newer devices in this manual.

The Projectionist himself must rely on many other factors – good equipment, well serviced – good films free from scratches and damage – a well-maintained theatre. In this last item, a good management team including the Projectionist is important. The seating, ventilation, lighting and acoustics all contribute greatly to good presentation by ensuring patron comfort. In the selection of equipment, spares and servicing, the Manager who has a broad knowledge of projection needs, can help the Projectionist enormously by realising the good economics of sensible spending to keep equipment in first-class condition. We hope this Manual will be of value to all Managers.

The Renters and Distributors, too, by good film servicing have an important part to play, but the Projectionist must always make sure that he himself is not contributing to film damage. We regard film handling as one of the essential skills for projectionists.

It is our intention in this Manual to make sure that the Projectionist, and all those associated with his work, has at hand all the information which he needs to play his all-important part in the efficient and unobtrusive presentation of films.

Motion Picture Presentation Manual

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A note on Metrication

In accordance with current recommendations we have specified all general dimensions in the Metric system for this Edition of the Manual. But where an exact length of film has to be indicated, as in Section 6 on Leaders, this is given in feet and frames, since here we are concerned with a number of frame intervals and a metric length would be both inconvenient and imprecise. Some projectionists of long experience may be unfamiliar with the nominal capacity of spools in metric terms: we have used the following equivalents

600 m	equivalent to		2,000 ft.	nominal
1200 m	”	”	4,000 ft.	”
1800 m	”	”	6,000 ft.	”
3000 m	”	”	10,000 ft.	”
4000 m	”	”	13,000 ft.	”

Bernard Happé FBKSTS

Editor for the Technical Advisory
Committee of the British Kinematograph,
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CONTENTS

CONTENTS (Continued)

The Care of Film

1. THE POSITIVE RELEASE PRINT

In that most release prints shown in cinemas today are in colour, the discussion which follows will concentrate on colour release prints. Many aspects of the preparation of colour release prints will also, of course, apply to black-and-white release prints.

The typical colour film used in cinemas consists of three emulsion layers, sensitive to green, red and blue light respectively and coated as a "sandwich" onto a single support or base. After exposure and processing the layers will contain magenta, cyan and yellow dyes in proportion to the amount of exposure given. In this way full colour images are built up; with a proper choice of dyes most colours found in real life can be reproduced satisfactorily.

The process of providing a colour release print to the cinema is a complex one. It starts with the exposure of the colour camera negative film, its processing and the preparation of rush prints. The next stage is the assembly of the rush prints into final continuity, making dissolves, special effects and titles, finally arriving at a complete cut negative ready for release printing. Whilst all this work is going on, the sound negative, containing dialogue, music and sound effects is being prepared, ending up with a master sound negative synchronized to the final cut negative.

The next step is to grade or "time" the picture negative both for its density level and colour balance, so that the whole when printed has a uniformity of density and colour quality suited to the mood of the picture. At the same time the master sound negative is graded so that the print has satisfactory quality and volume. With today's sophisticated electronic equipment, the laboratory can carry out the above operations quickly and efficiently, so that the first or second answer print is accepted by the customer.

At this point the laboratory is now ready to make the release prints for use in the cinema. However, before doing this, they often make a colour master positive from which a colour duplicating negative or negatives may be made. This colour duplicating negative may either be used to replace damaged original negative sections, or complete duplicating negatives may be sent abroad so that releases can be made with appropriate dialogue.

Typically, the Bell and Howell Model C Printer is used to make the release prints. This printer is a "continuous" printer in that the release print film and the negative, in contact, moves continuously past a uniformly illuminated slit. The grading information obtained above, is coded onto a tape and this tape is used to modify the slit illumination with respect to its colour and brightness to obtain the desired result on the print. The sound negative is similarly printed onto the release print film. The model C printer normally runs at 180 ft/minute, but recently some laboratories have installed printers running at 500 ft/minute or more.

After printing the colour print film is developed, fixed, bleached, refixed, washed and dried. A special process step immediately after the bleach allows for the sound track area only, to be developed to a silver image (the picture contains dyes only).

In order to achieve good reproducability between prints, the laboratory exercises careful technical control over the printers to ensure consistency of exposure, and over the developing equipment to ensure consistency of the chemical constitution of the various solutions, as well as careful control of temperatures, times and agitation.

At all stages in the production of a release print many individuals in laboratories are concerned with providing the cinema with high quality prints. The projectionist for his part should note two points which are particularly applicable to colour prints. Firstly to obtain the most pleasing presentation in the cinema, the screen brightness should be maintained at the recommended level. Failure to do so will result in a "washed out" appearance to the colours (high screen brightness) or dark muddy colours (low screen brightness).

Secondly the characteristics of the dyes used in colour prints are such that little heat from the projector light source is absorbed by the film during projection – black and white prints on the other hand do absorb some heat. As a result colour prints rarely suffer from focus problems due to film buckle, whilst the problem has to be guarded against with black and white prints.

2. PREVENTING DAMAGE TO RELEASE PRINTS

Damage due to Handling

It is the aim of the renting side of the Industry to supply prints in first-class condition and in good time for the opening date for which the subject is booked.

Prints start life as new copies which will put on a faultless show. There are, unfortunately, many ways in which films become damaged and each such defect spoils the enjoyment of the public. Apart from accidental damage it would be simple to eliminate practically all of the types of damage films now suffer.

Release Prints

From its first run a print starts to deteriorate and the speed of deterioration depends on many factors which will be dealt with under their various headings.

In general, reels of film delivered for screening are correctly packed, each in its own can properly labelled, with the clear spacing taped down to prevent damage to the leader. Small reels should not be placed into large cans – the less spare space in the can the better. This decreases the possibility of damage in transit. Clear spacing at the fronts and ends of reels is there to protect the Academy leader and the End of Part titles. The Standard leader is an integral part of a reel and matches "change over" cues at the end of the preceding reel, and upon its length and subsequent maintenance depends the success of "change overs" from one projector to another.

The proper make-up of leaders and cue marks is more fully described in Section 6 of this Manual. Should a film be received at a theatre without cue marks, the projectionist must add them at the appropriate positions, preferably using a mechanical cue marker. But if this is not available, the small circles used on a laboratory print should be copied by using a scriber, or a coloured grease-pencil if nothing better is at hand. But never make large scratched X's or felt-tip pen marks or large punched holes which cover the whole picture area for several frames. A professional projectionist will never mutilate his film in this way.

Leaders are often damaged due to the "snatch" when a projector starts up and perforations may be torn. Where this is found, the damaged perforations should be removed and a join made, keeping the correct frame position in rack. Because leaders are subject to strain, damaged perforations should never be repaired as "V" cuts: V-cuts weaken the film and make it tear much more easily.

As long as reels of film are handled as the traditional 600 m (2000 ft) reels it should never be necessary to remove the original Head Leader and Run-out sections. But with modern long-play equipment it is essential for the projectionist to take off these lengths in order to make-up into longer rolls. But for the benefit of the next operator who may have to show the film, it is absolutely necessary that all leaders and run-outs should be correctly replaced before the copy is passed. The procedure to be followed is more fully described in Section 5 of this Manual, Film Handling for Long Play Presentation, and should be carefully studied. A professional projectionist will never pass on a print in a form which can cause great inconvenience to the next user through the loss or wrong assembly of leaders.

Centre Support

All reels of film require support of the centre, particularly the double reels. A plastic 50 mm core as supplied by the stock manufacturers or a solid wooden bobbin under-cut to about 48 mm is undoubtedly the best centre support. Without such support, reels dropped or carelessly handled in transit would suffer considerable damage of the inner convolutions due to impact. Recently it has become the habit of many projectionists to use either a split spool or a 50 mm bakelite bobbin on the take-up spindle at their last showing and to return the reels to the Renters without rewinding. In many cases the centre support is omitted. All reels should be correctly rewound and examined after the last showing so that the projectionist knows the condition of a film after he has finished his run.

Rewinding

It is the practice in many Projection Rooms for rewinding to take place base side of the film uppermost. Scratching on the emulsion cannot be detected when films are rewound in this fashion, so all rewinding should be done with the emulsion side of the film uppermost. In many instances a whole copy and indeed a whole programme has suffered the same emulsion scratching throughout because the film had been rewound base side up, making it impossible to detect an emulsion scratch.

Where something on a projector is causing scratching, this should be noticed on rewinding the first reel damaged so that whatever is wrong can be rectified and thus prevent any damage to further reels.

Careless rewinding which leaves the edges proud and uneven can be responsible for the damage of long lengths of perforations, particularly if the edges stand higher in the can than the depth of the can; all reels should be plated off perfectly flat. Rewinding is not a job for a junior – this is an operation requiring skill. "Plating off" from spools after the last showing should be the responsibility of the "chief" who should make sure the film is free from damage and is ready for immediate use whether it is being "crossed over" or returned to the Renter.

Rewinding

1. Make sure your two rewind heads are perfectly aligned.

2. Rewind at moderate speed. Slow up towards the end so that the end does not flap.

3. Never leave slack film between the rewind heads and then take up with a jerk.

4. Loose rewinding causes abrasions but tightening a reel by pulling on the outside layer causes even more.

5. Stop several times at random and really examine both surfaces carefully.

6. Do not use a split spool on the last show, sending the film away unexamined.

7. If a spooled-off reel shows proud edges, never bang them down. Rewind the reel evenly.

Joins

Where joins are made in any part of a reel they should be perfectly made in all respects, the emulsion on the overlap should be completely removed and the base itself should be roughened to clear it of the binder layer so that the cement is applied to the base proper. The base side of the film to which the lap is to be joined should also be lightly scraped so that the base itself is exposed; the join should then be completed with an adequate cement under pressure, allowing a few seconds for the cement to act. The type of joint may vary but a full hole join is recommended. Imperfect joins are the main cause of breakdown during screening, and are also responsible for such serious defects as the film riding over the sprocket teeth and so tooth-marking the track and picture areas – such damage means re-printing. There is more information on this subject in Section 3 of this Manual, "The Importance of Good Film Joins".

Oil on films

Oil should never be allowed to get on to the film, as apart from impairing the quality of the picture on the screen, the film becomes very difficult to handle and particularly hard to wind flat and tight when being plated off. Oil is the usual cause of film not being wound flat and this can cause proud edges with the resultant damage that follows. The oil also picks up dirt particles and dust and retains it. A dry film with the proper hard wax coating remains clean very much longer.

Broken perforations

It is the practice of many projectionists where one perforation is split to put in a "V" cut. Although this weakens the edge of the film and makes it more liable to tear at this point, provided the "V" cut is properly made it will carry the film through the projector. "V" cuts however are not to be recommended, and for safety in projection a perfectly made join is preferable. Some projectionists make "V" cuts where two neighbouring perforations are damaged and this is a very dangerous practice and should never be resorted to. Where two perforations next to each other are damaged a join should ALWAYS be made. And never make a "V" cut on a join.

Cleanliness

All parts of a projector should be kept scrupulously clean, particularly the film-path. Scratching, the main cause of emulsion damage, is usually caused by some extraneous matter coming up against the film on its passage through the projector. More re-prints have to be made on account of heavily scratched emulsion than any other cause. If a projectionist is unfortunate enough to receive a badly scratched film, a report to the Renter concerned should be made immediately, so that the previous user can be traced and to make sure that what has caused the scratching is found and removed before further damage to other films is done. In handling film it is strongly recommended that cotton gloves be worn.

Waxing or lubrication of film

It is the practice of most renters to have films waxed by the laboratory that does the film printing. This waxing should be sufficient to take the film through the projector on its first few runs without the shedding of emulsion from the perforation margin. It is, however the practice of some projectionists to wax new films as a further safeguard against emulsion piling up in the picture-gate, and where this is done the lubricant should be applied with very great care so that there is not an excess of wax that is likely to spread across the sound track on to the picture. Paraffin wax should be applied very sparingly and in such a way that it keeps to the perforation edges only. Wax polish should not be used. Many waxes sold for furniture, etc., contain silicones which can cause image fading and other defects. The hard waxes used in the laboratories have been selected after much scientific investigation and are adequate and superior to anything the projectionist himself may fancy.

Wilful mutilation

The films should be returned after use in exactly the same condition as received. If this were a standard practice in every projection room and the necessary care taken by the first run operator onwards, damage would become almost non-existent and would make life very much easier for all who have to handle film. A little carelessness can cause faults in a print after a relatively few runs. When damage occurs it is always advisable for the projectionist responsible to report what has happened immediately to the Renter. This allows the Renter in the first place to see that the copy is not crossed over in a damaged condition to another exhibitor, and also allows adequate time for re-prints to be made where necessary. If damage occurs of which the Renter is not aware the print can be crossed over to another exhibitor who, most unfairly, is prevented from putting on a good show.

Speedy and frank co-operation with the Film Renter is to be commended. Such a policy pays handsome dividends in the end.

Bad packing

When a film is ready for returning after the last performance great care should be taken that it is properly canned in its right tin with the lids put on securely. The transit case should be securely closed. Keep the inside of a transit case absolutely clean so that there is no possibility of dirt or extraneous matter coming in contact with the film itself.

The "condition" of a film, i.e. scratching, jumps in continuity, trained and split perforations, bad joins – is the result of treatment received in projection rooms. Projectionists have the remedy in their own hands – greater care in handling by all those concerned would soon become a "chain reaction" and each projectionist would be receiving material, even on direct cross over, that would be trouble free.

Here then are some reminders:

1. Never let a reel of film with a large unsupported centre space flop about on a spooling plate hub or rewinder spindle.
2. Never overload a spool so that outside layers of film can fall off.
3. Rewind and examine every foot of film before re-using no matter how good it may look.
4. Keep a log book of titles, copy numbers and condition reel by reel, as received and as sent out again.
5. Report "damage as received" to your Manager so that he takes appropriate action immediately.
6. Check that there is 8 ft. of protective film and a Standard Leader on every film received.
7. Check every join for reliability.
8. Never use a bent or untrue running spool.
9. When examining hold the film with the hand below the film, emulsion up, and do not cup the film.
10. Don't make "V" cuts, make a good join.
11. Avoid removing leaders but if it is really unavoidable, put them carefully aside and rejoin them in place before sending the film back.
12. Never allow films to trail on bench or floor.

13. Where no bands are provided to protect the outside layer, tape it down to prevent it loosening the reel in transit.

14. If you use the silver foil patches necessary in automatic equipment make sure they are removed before despatch. They are easy to remove and intended to be removed.

15. Make sure the centre is properly in place before despatch.

16. Make sure each roll is in its correct can.

Damage due to Projection Machines

The positive release print spends most of its life being run through quite a complicated mechanism, stopped and started 24 times each second and subjected to tremendous heat. There are many ways that the positive release print can be damaged during its passage through the film mechanism and soundheads and the only way to minimise the wear and tear and eliminate the unnecessary damage is to make sure that the equipment is working properly. Adequate and regular service, the timely replacement of wearing parts, strict cleanliness, and a thorough knowlege of the equipment and its weaknesses are the keynotes for the avoidance of projector induced film damage.

The majority of breakdowns of film during screening are caused by excessive gate tension. During tests carried out the breakdowns due to such troubles were TEN TIMES more frequent with a gate tension of 850 g than with a tension of 225 g. The recommended value is between 225 and 400 g.

Here are some other recommendations to prevent film damage.

1. "Fire Trap" Rollers. The first point of contact with the film; watch for collection of dirt or oily matter. Watch for rollers developing flat spots. Wash out the bearings with spirit and re-oil occasionally.

2. Signalling Devices and Pulse Pick-Off Rollers. Check for binding or wear.

3. Guide Rollers. Watch alignment with sprocket. Check for ridges. Watch tension springs. Check the bearings as in 1.

4. Sprocket Pad Rollers or Idlers. Check for correct spacing from sprocket. Too little will cause rubbing, too much will cause a run-off. Clean and lubricate the shafts periodically. Two thicknesses of film is the recommended clearance.

5. Gate Tension. The degree of tension on the film in the gate is of vital importance and should be adjustable. Test in the recognised manner with a short length of film and a spring balance, and keep to the recommended average tension of 225 to 400 g, but observe any recommendations made by the projector manufacturer.

6. Tension on Top Spoolbox Shaft. Enough, but not too much. Avoid a jerky film feed but be sure on the other hand that enough tension to cause perforation straining of the last few feet of film is not applied.

7. Intermittent Film Guide or Shoe. A part that causes a lot of film damage if not watched very carefully. See that the shoe is not "sprung" and that the guide or shoe is seated correctly with proper clearance when a gate is replaced.

8. Sprockets. A great deal of damage is due to faulty sprockets. Examine for wear and undercutting of teeth. Watch for damage to teeth. Make sure that projectors are fitted with the so-called "Foxhole" sprockets for Mag-optical and Stereo release prints. Much unsteadiness in projection is caused by dirty intermittent sprocket teeth. Make sure that they are really clean and free from emulsion deposit at the roots of the teeth.

9. Take-up Tension. Very important indeed. Excessive tension will strain perforations at the trailing edges. This can clearly be distinguished from leading edge damage caused by excessive gate or take-off tension.

10. Be sure that the loops made in threading the machine are not oversize. Big loops are often the cause of intermittent abrasions on the film.

11. Larger picture sizes need more powerful light sources and these engender enormous heat on to the small area of the picture frame. Some older projectors have inefficient heat filters or even lack them all together. The use of higher arc amperage in an effort to attain a brighter picture with such projectors can cause permanent embossing and even blistering of the film. This damage is irreparable.

12. In the winter months cold machinery and a cold projection booth can cause condensation on the film. Keep the projection booth at an equable temperature and give the machine a good warm-up before lacing up.

13. In removing hard emulsion NEVER use a metal tool. A plastic or hardwood tool should be used.

In order that the projectionist may be quite clear in his reports of damage we give some definitions of the more common types of defect.

1. **Scratching**

   (a) Cross abrasions – usually caused by the edge of a spool in rewinding. Diagonal scratches on either side.

   (b) Cinch scratches – usually caused by pulling on the outside of a loose reel. Short longitudinal scratches.

   (c) Random short scratches caused by contact with bench or floor.

   (d) Continuous straight scratches on either side – typical projector scratches caused by a fault on the machine.

2. **Centre Splitting.** Is rarely seen but is caused by cupping the film during rewinding – particularly when the film has become very dry and cold. Ideally the room should be humidified but in the winter keep a tray of water under your radiator.

3. **Curl.** Another effect of varying atmospheric conditions. Positive curl with emulsion concave and negative curl with emulsion convex.

4. **Spoking.** Is due to loose rewinding of film with curl. Rewind more tightly.

5. **S Bend** or Pleat. . caused by pulling the outside end of a very loosely wound reel.

6. **Buckle.** Caused by a difference in moisture content between the outer edges and the image area of a film. Excessive gate heat is a typical cause of this fault but bad storage conditions can also be responsible. The edges are shorter than the centre.

7. **Perforation damage.** Try to be specific – is the leading or trailing edge damaged? Is the fault due to pushing down protruding layers?

8. **Long edge or Flute.** The opposite of buckle. The edges are longer than the image area – probably due to bad storage conditions.

The use of the proper terms in reports means a quicker reaction from the Renter and a much more rapid and easy discovery of the source of trouble.

3. THE IMPORTANCE OF GOOD FILM JOINS

Joining motion-picture film is of such great importance as to merit special and constant attention. Although the transparent tape join is being used more and more, the cemented join remains largely in use and will be considered first.

Apart from the adverse effect on presentation, a large amount of film is ruined by poor joining. Joins that are over-width, stiff, buckled, or out of alignment are always liable to run off sprockets with resultant further damage to the film through run-off marking, straining or actual physical breakdown.

Furthermore, perforations in the vicinity of bad joins are invariably strained and may even have broken-down walls.

All reels of film contain joins; in older reels joins are more numerous – each join is a potential weak link in the chain of projection. Perfectly made joins will withstand the rigours of projection and rewinding indefinitely – imperfect joins will eventually come apart either in the rewinding process or on the projector.

Cement Joins

Hand made joining of the tri-acetate base (NON-FLAM) cannot produce satisfactory results, and this method of joining is thoroughly condemned. A first class modern joining machine must be part of the standard equipment in the projection suite.

Where joins are made they should be perfectly made in all respects, the emulsion on the overlapping part of the join should be cleared completely from the base and the base itself should be lightly roughened to clear it of the binder or adhesive so that the cement is applied to the base proper. The base side of the film to which the lap is to be joined should also be lightly scraped so that the base itself is exposed. This ensures that base is joined to base and also removes any dirt, wax or oil and creates a stronger join. Joins become necessary mostly where broken or strained perforations have to be removed and occasionally due to accidental breaking of film. Joins are far, far more reliable than "V" cuts. A "V" cut should never be made on an existing join that has become split and should never be used instead of a join where two perforations next to each other are broken.

Let us ensure good joining by reiterating 11 golden rules.

1. Use of Mechanical Joiner. There are many types available, from the automatic scraper de-luxe model to the very simple and not too efficient cheaper machine. The more expensive machine is cheaper in the long run as it saves considerable time per join and makes a perfect join in all ways.

   Splicers (joining machines) should at all times be kept scrupulously clean and all movable parts lubricated. After making a splice, all dust and film scrapings and surplus film cement should be wiped off the splicer – leaving the machine clean and dry in readiness for the next join.

   When moving parts become worn they should be replaced; worn parts create maladjustments which in turn can produce faulty joins out of correct alignment. Film scrapings often adhere to the film itself during the joining operation, so lightly dust the film with a soft cloth to remove this extraneous matter, which, if left adhering to film, will look like huge black spots on the screen.

2. Use Proper Film Cement. No matter how well the film is prepared for joining, the join cannot be completed without an adequate cement – make sure that the cement you use is fresh and of the correct type. There are several excellent cements available to choose from.

3. Preserving Film Cement. Use only a small quantity at a time, replace often and always replace the cork or stopper tightly immediately after use. Some volatile constituents evaporate more quickly than the remainder. Evaporation means deterioration and that leads to mutilation.

4. Cut in Rack. Always make certain in preparing to make a join, that the cut, when made, is "in rack" and completes a full "frame" – it is always worth a double check to ensure the "one hole" scraped lap is in fact a true frame-lap overlap.

5. Scrape Accurately. A good joining machine will cut the film exactly for the lap and frame involved but the scraping is left to the person concerned to decide the right amount to remove.

6. Scrape Thoroughly. All the emulsion and the binder layer must be removed from one end and the other should be cleaned of all oil and dirt or slightly roughened and any magnetic stripe removed – cement will not act upon emulsion, oil, wax or dirt. In the case of a film bearing emulsion on both sides, all emulsion and binder layer must be removed from both ends.

7. Apply Film Cement Properly. Apply a sufficient but not excessive quantity in one stroke of the brush – hard to judge at first but easy after experience.

8. Apply Proper Pressure. Immediately cement has been applied, pressure is required to complete the join. Pressure ensures absence of air bubbles between the films being joined and also presses out any surplus unwanted cement. Do not slam down the right-hand pressure clamp.

9. Apply the Pressure Long Enough. In most mechanical joiners the required pressure is supplied automatically by the closing down of the machine. Keep the join under pressure for about 20 seconds.

10. Blooping of Optical Joins. Joins made on a precision joining machine do not as a rule require blooping, but where blooping is considered necessary an elongated triangle with its peak pointing to the inner edge of the track is permissible, but every care must be taken to avoid the blooping ink getting on to the picture itself.

11. Cleanliness. Every time a lap is scraped thousands of small particles of emulsion dust and base dust are produced. The utmost care is necessary to keep bench and joiner clean and free from dust. Film becomes charged with static electricity when rubbed with a cloth and all these small dust particles are attracted to the film.

Motion-picture film is composed of three layers – the relatively thick base material, and the two thinner layers, the emulsion and the "binder". The binder layer binds the emulsion to the base and it can be easily forgotten. This must be completely removed from the base or the join will be useless, rapidly falling apart. A good join is as strong – sometimes stronger – than the unjoined base – it really forms a weld.

Types of joins vary but the 3.96 mm (0.156 in) full-hole overlap join covering one perforation is the one that carries the confidence of most projectionists and is recommended.

When joining Magnetic or Mag-Optical prints it is recommended that a 1.83 mm (0.072 in) join between the perforations is used. It is most important that a non-magnetic joiner is used and that the overlap be as shown in Figure 1, in order that the edge of the lap shall not damage the pole faces of the magnetic heads.

In many instances the cause of poor joins is blamed on the film cement being used or even on the characteristics of the film itself, but the real cause is more likely to be neglect of attention to the basic rules of joining.

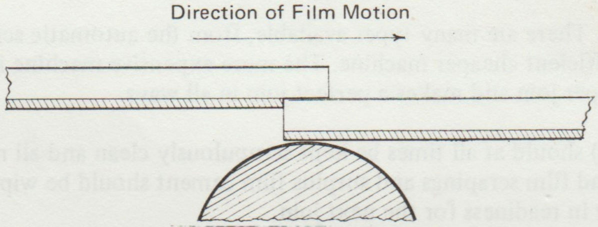


Fig.1

Tape Joins

In recent years a method of joining using a very thin transparent adhesive tape has come into use. Since tape joins can be separated and remade without the loss of frames of the picture they are particularly useful in making up the large rolls required for long-play presentation. But it is essential to use the special adhesive tape designed for motion picture use: the normal transparent tape supplied by a stationer's shop is not strong enough and the adhesive will ooze out at the edges with the heat of the projector.

Tape splices may be made with the ends of the film overlapped or butted together, according to the type of machine used, and the tape may be pre-perforated to the required hole size or unperforated, in which case the holes are punched in the correct position by the joining machine. In both cases the tape is applied to both sides of the film for normal projection practice.

No matter what type of tape splicer is used, it is essential to pay careful attention to cleanliness, technique and materials. The film surfaces must be clean and free from oil: dirt will cause bubbles under the tape and oily film will prevent proper adhesion. The cut ends of the film must be neat and square so that the film is kept properly aligned for both butt and overlap joins.

Don't allow the tape to overlap the edges of the film – check the action of the automatic trimmer if one is fitted and if it is not perfect, smooth it off with scissors or razor blade so that it isn't over-width. On the other hand, don't apply tape in the picture area only: the corners may lift and catch up somewhere in the projector path.

If a completed tape splice looks untidy or creased when finished, re-make it: carefully lift the corner of the tape on one side with a knife or razor blade and peel it off. Then remove the tape on the other surface of the film and start all over again. Well-made tape splices are strong and very unobtrusive: don't leave a splice that will draw attention to poor workmanship.

Similarly, when breaking-down a made-up roll at the end of a show, remove the tape at the joins with care, don't just tear the film across which may damage and lose a number of frames.

4. THE LUBRICATION OF FILMS

Waxing

The rudiments of film processing are generally known to most projectionists. These cover printing, which is a dry process, followed by the immersion in baths for developing, fixing and washing, during which process the film becomes thoroughly wet. As all the moisture is not removed from the gelatine emulsion in the drying process, there is no doubt whatever that normal film as it comes off the end of the laboratory machine is not really ready to stand up to the hard wear of release projection, even if it has been subjected to a hardening treatment such as a formalin bath or a chrome alum type of bath.

Most laboratories therefore wax the perforation area or even wax the whole surface. This is necessary to prevent the soft emulsion, when subjected to the heat of the picture gate, from becoming tacky and shedding on to the gate runners causing the "Pile-up" which scores the perforation margins and strains perforations.

Apart from the early runs, waxing is important throughout the life of a film. A reel of untreated film for instance, if forced into a cone and then flattened, will show the usual horizontal cinch marks and if loosely wound and then tightened by pulling on the outside turns will show longitudinal short scratches or cinch marks.

This condition is made worse by using oil or sticky wax. Moreover films maltreated in this way are almost impossible to wind flat and many "proud" edges will be found in such rolls. Ninety per cent of edge damaged film is found to be oily. Oil also produces mottle on the film surface giving the effect of unstable sharpness on the screen.

The use of machine oils, floor waxes and similar commercial lubricants is the worst thing to do. Many of these oils contain fatty acids and many of the polishes contain silicones both of which can affect image colour (even in black and white film).

Projectionists are advised not to resort to "do it yourself" waxing. If an emergency does arise a little paraffin wax applied to the perforations can be used – but this wax flakes and soon causes a very dirty copy. Report any such difficulty to the Renter.

Magnetic Prints

When magnetic stripes are to be applied to the processed print for magnetic sound recording, it is not possible for laboratory to wax the copy after developing in their usual way, since the magnetic stripe will not adhere to a waxed surface. It is therefore most important for the organisation who finally prepares the copy for distribution should see that it has been adequately lubricated **after** the magnetic sound record has been added.

Cleaning

Frequently, films become saturated with oil and other greases.

Cleaning is best left to the Renters who have at their disposal the services of laboratories that specialise in film cleaning.

Sometimes over-waxing is responsible for wax spreading on to the picture surfaces, and this, as well as any other type of oil or grease, will hold dirt and dust which if not removed from the surfaces of the film will have a disastrous effect on the screen. There are only a few ways of cleaning film adequately. The best method is with a properly designed cleaning machine where the film is immersed in the cleaning liquid with soft hair brushes revolving in the liquid against both sides of the film. By this method the soft bristles are able to remove dirt, grit or grease that has become embedded in scratches on either the base or emulsion.

If, however, a projectionist receives a really oily or dirty copy which he must use for a show, he needs to deal with the situation immediately. This requires cleaning by hand, and the procedure here is to moisten a very soft lint-free cloth or rayon plush cloth moistened with an approved cleaning fluid which is held in the hand in such a way that both sides of the film come into contact with the moistened material. Winding during this process should be very much slower than usual. Use good quality fluid, free from the sulphur derivatives, which can give the emulsion a brownish tone.

It is essential that the cloth used is quite clean and free from any dirt, grit or dust as dirty material could quite easily cause a series of scratches. Also if the material is held too tightly against the sides of the film, the pressure even with clean material could cause shallow scratches to appear.

Never run the film through a dry cloth – this will only spread the oil on the film and cause scratches through grit picked up in the cloth. As the cloth gets dirty, re-fold and re-moisten.

Whilst the above method is quite effective as a means of cleaning by hand, it is essential to point out that cleaning of this type applies to normal optical prints only and under no circumstances should this method be used for prints with magnetic or magoptical tracks.

The cleaning of film is a process requiring considerable care and should not be attempted by the unskilled.

If a copy is received in a seriously oily or dirty condition, report it to the Renter immediately.

5. FILM HANDLING FOR LONG PLAY PRESENTATION

In this context, "long play" means any film which will be projected in lengths greater than the traditional 600 m (2000 ft) reels in which the majority of feature film release prints are manufactured at the laboratories and distributed from the exchanges. Whether large spools of 1800 m (6000 ft), giants up to 4000 m (13,000 ft) or platter rolls of possibly 7500 m (24,500 ft) are to be run, the projectionist has the task of making up the separate cans of film which he receives into the exact form in which it is to be shown, and, equally important, breaking it down again at the end of his period of use so that it can be re-packed in its 600 m cans for transport to the next theatre. There are some moves on foot to manufacture and distribute prints in larger rolls but until all cinemas in the country can accept these, many projectionists will have a routine job of rewinding and joining every time a copy moves in and out of his theatre.

Unless this job is done carefully at both make-up and break-down stages by every operator concerned, damage will be caused to the print and the task of the next projectionist to receive the copy made more difficult. So remember both the cash customers in the audience of your own theatre and your opposite number in the projection box at the next and take this business of film handling for long play presentation as seriously as it needs.

Splices

Making up a complete programme may require anything from six to ten joins and the break-down afterwards possibly twice as many – and they **all** have to be good. So study Section 3 of this Manual and make sure your technique for film joining is truly professional.

Tape joins are becoming increasingly important as the amount of make-up increases: even a good cement splice causes the loss of two frames of the picture every time a join is undone and remade, so an appreciable length can be lost at the beginning and end of reels in the course of a few weeks' distribution, causing annoying gaps in the action and sound. Tape joins on the other hand can be undone and remade many times without losing frames if the tape is carefully peeled off whenever the film is to be taken apart.

Make-up and Break-down

When you are making up a large reel for the first time you have to remove the leaders and trailers from the head and tail ends wherever parts are to be joined for continuous running. These leaders contain the essential identification of the subject title and reel number and it is most important for the next projectionist using the copy to make sure that they are correctly replaced before passing the print on.

When removing leaders and trailers for the first time it is helpful to identify the main body of the reel so that it can be matched to its correct ends when these are replaced. Some projectionists leave the first and last picture frames attached to the leaders so that these can be seen to be a match to the body of the reel when they are brought together again. Of course if the picture begins or ends with a fade, it is necessary to make some sort of small additional mark, for instance the part number, on the two ends for matching later.

An important requirement in breaking down a print which has been assembled for long play presentation is to make sure that the leaders and trailers are replaced at exactly the correct positions from which they were previously removed. When the continuity of a feature film is originally created at the studio, the editor gives very careful consideration to deciding just where each reel shall begin and end, preferably at the conclusion of a complete sequence or at a change of location, so that the transition from one reel to the next shall be as smooth as possible. So when breaking down a large reel assembly it just isn't good enough to wind off about 550 m (1800 ft) or so and cut the film anywhere before replacing the leaders. You must find the correct reel end positions where the joins were made during make-up.

Locating Joins

So it makes good sense during the make-up operation to use some indicator marks which will help you to find the joins again when you come to break down at the end of the programme. But do make sure that these marks don't mutilate the film or show in the picture area. Grease pencil is not a good thing to use because it can transfer to other parts of the film: if it must be used, make sure that the marks are only on the edge of the film outside the perforations.

If you are using tape joins, there is a white translucent polyester tape 1-inch wide available which is quite easy to see on the film while rewinding but is transparent enough not to be too obvious on the screen when the join runs through the projector if less than two frames are affected.

Another method is to apply a short length, about 2 inches, of white polyester Perfix repair tape to the edge of the film at the tail end of the reel just before the splice. This tape is pre-perforated and is normally used to repair broken or torn sprocket holes but when used as a reel-end marker it is very easy to see and once applied can be left permanently in place for the benefit of subsequent users.

In the absence of anything better, it may be possible during the last showing of the made-up roll to insert a paper tab marker between the film turns on the take-up reel or platter turntable as each splice is heard to go through the projector gate. The tab will not give the exact location but when re-winding on break-down it will be an indication when to slow down and look or feel for the join itself.

To summarise, in addition to the care and attention which must be given to all film, remember especially when using long playing equipment

REPLACE ALL LEADERS AND TRAILERS ON THE **RIGHT** REELS
AND AT THE **RIGHT** POSITIONS

so that the copy goes to the next theatre in good order, as you would like to receive it yourself.

6. LEADERS AND CUE MARKS

The lengths of film before and after the main picture material in each reel manufactured by the laboratory are provided to help the projectionist in his work and should therefore be treated with respect. These leaders and trailers, sometimes also called the head and tail leaders, have three functions:

1. **Protection** At the very beginning and end of the roll there should be a length of 2 to 2½ metres of blank film to take the wear and tear of threading and unthreading the projector path, rewinding and transit. This may be unprocessed raw stock, blank or clear film or even lengths of scrap print. With repeated use, the extreme ends will become torn or broken off, which gradually shortens the protective length, but these sections should be replaced when less than about 2 metres remains, so that there is always enough for handling.

2. **Identification** The first portion of the printed copy is the identification section, giving the title of the film and the part number, preceded by the word HEAD in bold letters, so that there is no doubt which is the beginning of the roll. The title and part number are shown in two forms, one along the length of the film, which is easier to read when rewinding, and the other within separate frames. There may also be information for the type of projection (Anamorphic, Wide-Screen 1.85:1, etc.) and the level at which the sound fader is to be set.

   At the end of the roll the title and part number is similarly repeated, together with TAIL or END in large letters.

3. **Synchronisation** The remainder of the Head Leader is known as the Synchronising section and is designed to help the projectionist thread-up the film correctly in preparation for the show. Near the beginning of this section is a frame marked START or PICTURE START, while 20 frames ahead of this will be found the corresponding point for the optical (photographic) Sound start. This frame is usually marked with a clear diamond on a black background, sometimes with the numeral 35 beside it, but in some leaders the words 35 SOUND START are shown in full. Other markings may be $\frac{35}{0}$ or $\frac{35}{P}$. The centre of this frame, marked by the middle of the diamond or a clear line, must be at the optical sound head of the projector when the START frame is correctly centred in the Picture gate in order that the optical sound shall be reproduced in correct synchronisation with the action.

   Some leaders also show a synchronising frame for 35 mm prints with magnetic sound tracks, marked 35 MAG or $\frac{35}{M}$, 28 frames **after** the picture Start. When reproducing magnetic tracks the centre line of this frame must be at the sound head cluster above the projector head when the picture Start frame is in the gate.

The Count-down Numbers

The picture START is always printed at a distance of 192 frames (12 feet of 35 mm film) ahead of the beginning of the first scene in the reel. In the Academy type of leader, which is still the most frequently used in the cinema theatre, the intervening space is made up of black opaque frames, preferably with clear inter-frame lines, and a series of clear frames at intervals of one foot (16 frames) from the Start successively numbered "11", "10", "9" etc down to "3". The last 48 frames immediately preceding the first scene of the reel are uniformly black.

In this "count-down" section the Sound Head position for any numbered frame is marked with a diamond 20 frames ahead; the projectionist can therefore check his thread-up anywhere in this section by noting that there is a diamond opposite the optical sound head whenever there is a numbered frame in the picture gate.

Two variations on this type of leader may be found; the original Academy form is a carry-over from the days of the silent cinema when film ran at 16 pictures per second and the count-down numbers represented one-second intervals. This of course is no longer the case for projection at 24 pps. Television users of film however like to work very precisely in their timing and in 1965 the American Society of Motion Picture and Television Engineers (SMPTE) introduced what was termed the SMPTE Universal leader, in which the count-down numbers changed at 24 frame intervals (numerals 7 to 2 instead of 11 to 3) and all the intervening frames showed a rotating wedge as an animated one-second clock for split-second timing. However this form of leader has not yet been extensively adopted for theatrical use, even in the United States. The current international standard, ISO 4241, also includes count-down numbers at 24 frame intervals, but in this the intermediate frames are opaque. The new British Standard BS 5550:5.5.2:1978 is similar but has not yet been put into use.

Cue Marks

At the tail end of the reel, the trailer always contains a run-out section of 48 opaque frames after the last picture before the final identification section; this is a safeguard against the possibility of a late change-over.

When running a continuous show on two projectors it is of course essential that the change over from the end of a reel on one machine to the start on the other is done promptly and at exactly the right place, so that there is no apparent break in the action on the screen. The skilled projectionist is best recognised when the audience is quite unaware that he has made a change at all!

The last portion of the picture carries two sets of visible cue marks to help the projectionist at each change, in the form of small dots or circles which appear in the upper right-hand corner of the picture on the screen. One set, the actual change-over cue, are marked on four consecutive frames 24 frames before the end of the picture. The second set, the motor cue, are on four consecutive frames 168 frames ahead of the change-over set. The appearance of the first motor cue on the screen is a warning to start up the motor of the second machine and when the change-over cue is seen the change-over switch must be operated, which closes a shutter in front of the first projector and opens up the second, at the same time switching the sound reproduction from one to the other.

It is essential that the second machine should be fully up to speed when the change-over is made: if projectors started instantaneously it would be correct to have the leader of the reel on the second machine with the Picture Start frame in the gate, so that it would have run through the full 12 feet of the count-down leader to the first picture by the time change-over took place. But in fact all projectors take an appreciable time to get up to speed from a stationary start and the projectionist must learn by experience just how much of the count-down leader will be run through during the 8-second interval between the motor cue and the reel end. Once this has been found out for a particular machine, the count-down numbers can be used for the correct thread-up position in all future cases. For example, if on starting up the projector has only run through 128 frames of the leader, the projectionist will know that he must always thread up on the count-down frame marked "8" (8 x 16 = 128) in the projector gate to make a good change-over.

Practical Problems

Unfortunately the beginning and ends of reels are liable to become damaged in the course of use and, especially when the leaders and trailers are removed and replaced during handling for long-playing presentation, the loss of frames at the end of the picture may eventually reach the change-over cues. If it is then necessary to re-mark the cues, make sure that it is not done in a way that mutilates the film. Cue-marking devices which scribe the required small circles in the right position are available and should be found in a well-equipped projection room. But even where these are not to hand, do try to copy the proper marks in the form of a small circle, just under 2½ mm (1/10 in) across, in the top corner of the frame on the side opposite the sound track. Big scratched crosses covering the whole frame, wavy lines of grease pencil or felt-tip pen or large holes punched out of the middle of the frame are all very distracting to the audience and show a poor standard of work which no self-respecting projectionist should carry out. If a print has lost its cue marks, take the time and trouble to replace them as nearly as possible in their original form.

At the beginning of the reel, sections missing from the synchronising leader can cause mis-timed change-overs, so when first examining a copy on arrival at your theatre, make sure that this section is complete. If there are splices, check that any lost frames have been replaced. In the Academy leader there should be nine places after the Picture Start showing numbered frames 11 down to 3 and there should always be 16 frames from one number to the next.

This examination of the head leader will also warn you if the copy has one of the less common leaders of the SMPTE or ISO types, which show numbers 7 down to 2 at 24 frame intervals. With these you will have to remember to thread up at a different number from your regular Academy position. For example, if your normal practice is to thread up on the count-down number "8", which is (8 x 16 =) 128 frames ahead of the first picture, the position in the SMPTE or ISO leader will be 8 frames before the first frame marked "5" to give the same run-up length, (5 x 24) + 8 = 128.

Occasionally other types of TV leaders may be encountered, all based on the 24 frame interval between numbers, but these will be infrequent in normal cinema theatre practice.

7. FILM HANDLING EQUIPMENT

Film handling equipment in cinemas varies enormously, from the most modern and costly equipment down to the bare essentials. But two basic items are indispensable: an accurately aligned rewinder and a good film joiner. With careful use and the utmost cleanliness the most basic equipment can do its job and safeguard the film. So let us list these fundamental units:

The Rewind Bench

A solid bench must be provided on which the rewinder is mounted. The bench should be of metal with a laminated top which is easy to keep spotless. It should be fitted with convenient drawers for the storage of dusters, white gloves, cleaning fluids and other accessories. A typical modern rewind bench is shown in Fig. 1.

Rewinders

A modern motorised rewinder with variable speed control is also seen in Fig. 1.

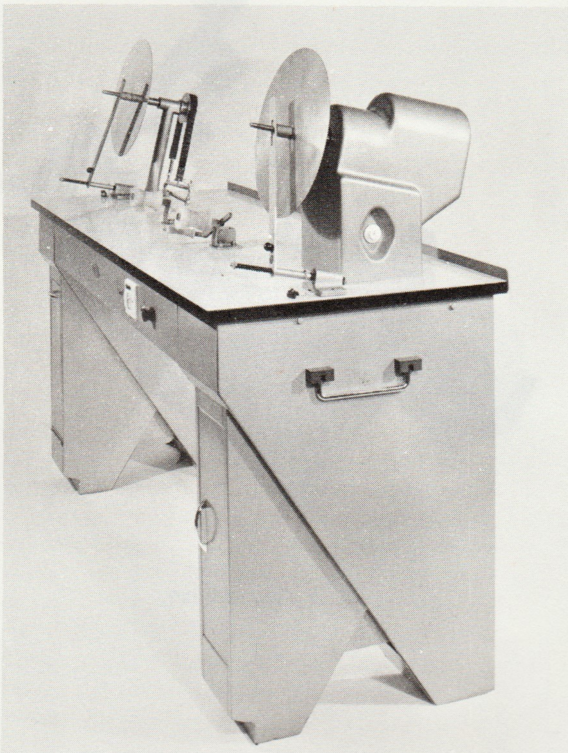


Fig.1. Motorised Rewind Bench.

Most rewinders have an idle spindle on the left-hand side and a motor-driven spindle on the right. For hand-operated machines the geared rewind unit will be on the right hand. Both spindles should be provided with a screw-on keeper, a backing plate and adaptors to take plastic centre cores. Plates and keepers should be inter-changeable between the idle and driven ends. The two ends must be correctly aligned so that there is no distortion on the film path which could cause damage or strain.

Spools

Whatever size spools are used, they must run truly: a bent spool or one with the slightest edge damage can ruin film faster than anything else. Such spools should be discarded immediately or returned to the manufacturer for repair.

Splicers

There are two basic types of film joiner, or splicer:

1. The cement type which nowadays includes a good scraping device which can be sharpened or replaced. It is important to see that the scraper and film cutters are kept really sharp – a blunt or clogged-up scraper causes poor joins.

   Film cement should always be kept in a stoppered bottle when not in use and should be kept away from the bench except when splicing is actually being done.

2. The tape type which applies a transparent adhesive tape to a butt join. The tape should be applied to both sides of the film. In many ways the tape joiner is to be preferred to the cement joiner. It is cleaner – the bench is no longer covered with emulsion shavings and dust after each join and the joiner itself is no longer contaminated with dried cement which must be cleaned off every time it is used. Tape splices can also be removed and remade without damage to the film or loss of frames at the join. (Fig. 2)

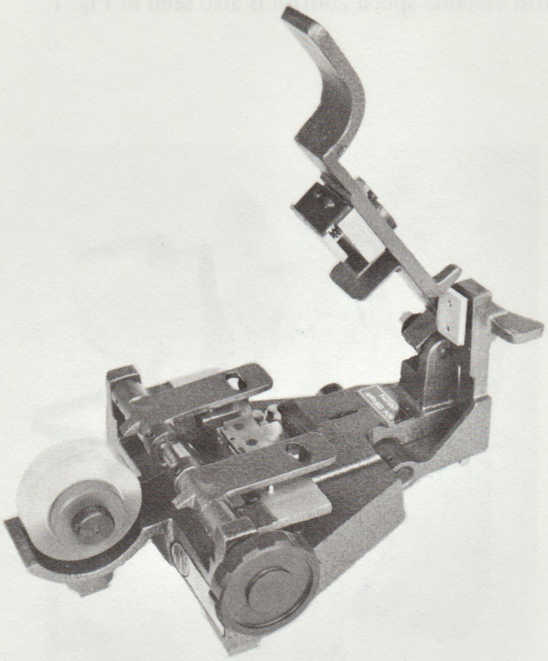


Fig.2. Tape Splicer.

Storage Cabinets

Storage cabinets must be large enough to take the spooled-up programme. At one time a series of 600 m compartments was sufficient but now cabinets for six 63.5 cm diameter spools taking 1800 m each are available in similar form. The spool compartments have individual doors, so that each compartment can be easily marked with the subject and part number, and the film is kept readily available and really clean.

Other Accessories

A Film Measurer, which is a sprocket geared to a counter, is useful for programme timing and film checking.

A Cue Dot Marker which registers the film in position and scribes the correct cue mark circles on four frames without damaging the film is a valuable tool and its use prevents much mutilation caused by crude cueing methods.

In a well-equipped theatre a bench-mounted Film Waxer can be provided for automatically lubricating prints in the perforation area during rewinding.

For the repair of broken or torn perforation holes without splicing (and the consequent loss of at least one frame of picture), Perfix polyester repair tape and its simple applicator is ideal. This applies pre-perforated white tape to the edge of the film, just within the perforation area and is quick and safe in use.

In an ideal theatre, the projection suite should always have ready access to a wash-basin with hot and cold water and clean towels. Projectionists have many oily and dirty jobs to do as well as handling expensive films!

Care and Maintenance

Wear cotton gloves when handling film, wash them when they become dirty and discard them when badly worn.

Keep the rewind bench and splicer scrupulously clean at all times.

Don't use stale film cement – it makes bad joins.

Apply a little oil to the lubrication points of the rewinders periodically.

Don't use the storage compartments as rubbish bins.

Discard bent or damaged spools at once – they are cheaper than film.

The Projector and its use

8. THE MOTION-PICTURE PROJECTOR – GENERAL

The modern motion-picture projector comprises a series of units brought together in a way that allows their efficient operation in inter-dependence, in spite of their individually complex and quite different natures.

The mechanical side of the projector is only one aspect for, apart from machinery, there is electrical equipment, electronic equipment, optical systems, thermo-electric devices, photo-electric devices and a high-powered carbon arc or a discharge lamp involved.

The options available in combinations of projector mechanisms, sound reproducing equipment, lamp houses for the normal – that is, traditional – type of projector, is enormous. A few projectors are completely integrated pieces of apparatus but this is the rare case.

In addition to what we can, for convenience, call normal projection equipment, there is a growing use of long-playing projectors, long-playing adaptors and continuous playing (that is, self-rewinding) devices.

Associated with these latter devices there are now available sophisticated automatic control equipments capable of running the whole of the programme – house lights, curtains, dimmers, sound and picture projection, non-synch. players of the disc or cassette type and so on.

These newer methods will be dealt with separately and the present data is confined to the more basic projection machinery.

For the purposes of this general description, the motion-picture can conveniently be dealt with under the following sub-headings. Individual items are dealt with elsewhere in other sections of this Manual.

a. The top spoolbox

b. The magnetic soundhead

c. The film-mechanism

d. The optical soundhead

e. The bottom spoolbox

f. The stand

g. The light source

a. **The Top Spoolbox.** This part of the motion-picture projector consists of a metal box into which the loaded spool of film is first inserted. The box has a central shaft to support the spool on which it rotates as the film is fed from the spool into the film-mechanism and soundheads. The spoolbox spindle is equipped with an adjustable friction device which holds the spool steady and prevents over-run due to momentum when the projector stops.

Where the film enters or leaves a spoolbox, generally through a slot, there is a narrow metal channel known as a fire trap and intended to prevent the passage of flame into the spoolbox should the film ignite. Since all film is now non-flam or safety type with slow-burning characteristics, there is little danger.

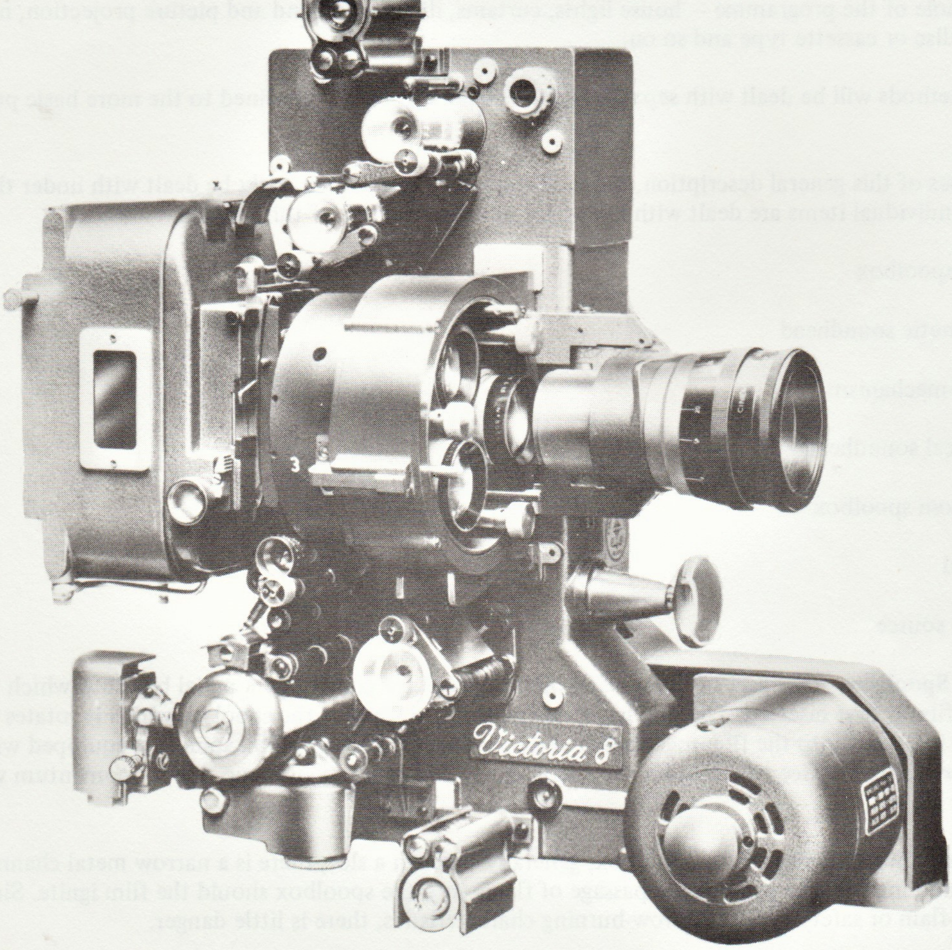
b. **The Magnetic Soundhead.** Known as the penthouse soundhead, this piece of equipment is fitted underneath the top spoolbox and above the film-mechanism and consists of a series of tension rollers and other smoothing devices to ensure even and steady movement of the film over the multi-track magnetic heads.

c. **The Film-Mechanism.** This is the section of the motion-picture projector which is concerned with the transport of the film through the picture gate, where an image of the film frame is projected to the cinema screen. The film-mechanism is certainly a piece of high grade precision machinery. It is, however, so constructed that it will operate satisfactorily under the most arduous conditions and during the long operating hours found in the average cinema.

Here we can break down again into sub-headings and consider the various items separately:

1. The take-off sprocket assembly
2. The intermittent movement
3. The shutter
4. The picture gate
5. The picture framing
6. The take-up sprocket assembly
7. The lens mounting
8. The safety shutter and changeover device

1. **The Take-off Sprocket Assembly.** This consists of a constantly driven film sprocket, sometimes called the top feed sprocket, which pulls the film off the top spool and feeds it to the picture gate and the intermittent sprocket. Associated with this sprocket is a system of guides and rollers intended to ensure that the film fits snugly on to the sprocket with its perforations meshing evenly with the sprocket teeth.



The head mechanism of a modern 70/35mm Projector (by courtesy of Rank Film Equipment).

2. **The Intermittent Movement.** During the time that the picture image is being projected to the screen, the film must be held perfectly steady and accurately in place in the picture gate. It therefore becomes necessary to translate a continuous feed movement into a stop-and-start movement and this is accomplished by the intermittent, the true "heart" of the motion-picture projector.

The normal type of intermittent movement used in a 35 mm projector consists of a maltese cross and a cam with a striking pin. The cam is driven continuously and when the striking pin enters one of the slots of the maltese cross, the cross is turned one quarter of a revolution. Then the locking face of the cam slides over the curved surface of the maltese cross and during this time the intermittent sprocket, which is mounted on the shaft associated with the maltese cross, remains stationary. The intermittent sprocket has 16 teeth and a quarter of a revolution involves four teeth which mesh with the four perforations of one film frame. On the end of the cam shaft there is a heavy flywheel to ensure smooth movement.

Since 24 picture frames are shown per second, the whole operation concerned with the stopping and starting of one picture frame must be 1/24th of a second. This period of time can be divided into 4/96ths of a second and during 1/96th of a second the film frame is moved away and the following film frame brought into position. It, therefore, follows that for 3/96ths of a second or 1/32nd of a second the film frame remains stationary in the picture gate while an image is projected to the cinema screen.

3. **The Shutter.** This is also a very important part of the film-mechanism. During the period of time required to move one film frame away and bring the following film frame into position (1/96th of a second) no light must reach the screen or there would be a picture defect. This would take the form of streaks of light known as "ghosting". The shutter is so arranged that it blocks off the light beam just as the film begins to move out of the picture gate and it opens the way again for the light beam to pass just as the next film frame comes to rest.

There is, however, a second function for the shutter. The projection of a motion-picture is an optical trick based on a defect of human vision. No true "motion" pictures are in fact shown: instead a rapid succession of still pictures is projected to the screen and persistence of vision serves to blend them into each other to produce the illusion of smoothly flowing motion-pictures.

Bound up with persistence of vision is another defect of human vision known as flicker perception. The eye will perceive flicker if the light interruptions are 24 per second and so it becomes necessary to increase the number of light interruptions per second.

This is easily done by using the shutter to make a second light cut-off (1/96th of a second) during the time that the film frame is stationary in the picture gate (1/32nd of a second). This doubles the flicker frequency, bringing it up to 48 interruptions per second, which is above perception except for very bright pictures.

Shutters of various kinds are to be found. There are two-bladed shutters of the disc type, single-blade shutters of the disc type, single-blade shutters of the disc type that rotate at twice normal speed, barrel shutters, dish shutters, etc., all having various advantages and various disadvantages in relation to light transmission and freedom from "ghosting".

4. **The Picture Gate.** This is generally a long metal channel through which the film is drawn while spring loaded runners press against the side margins of the film in order to hold it firmly and accurately in place. There are guide rollers at the entry to the gate channel and one section of the gate can be opened so that the film can be inserted in the channel.

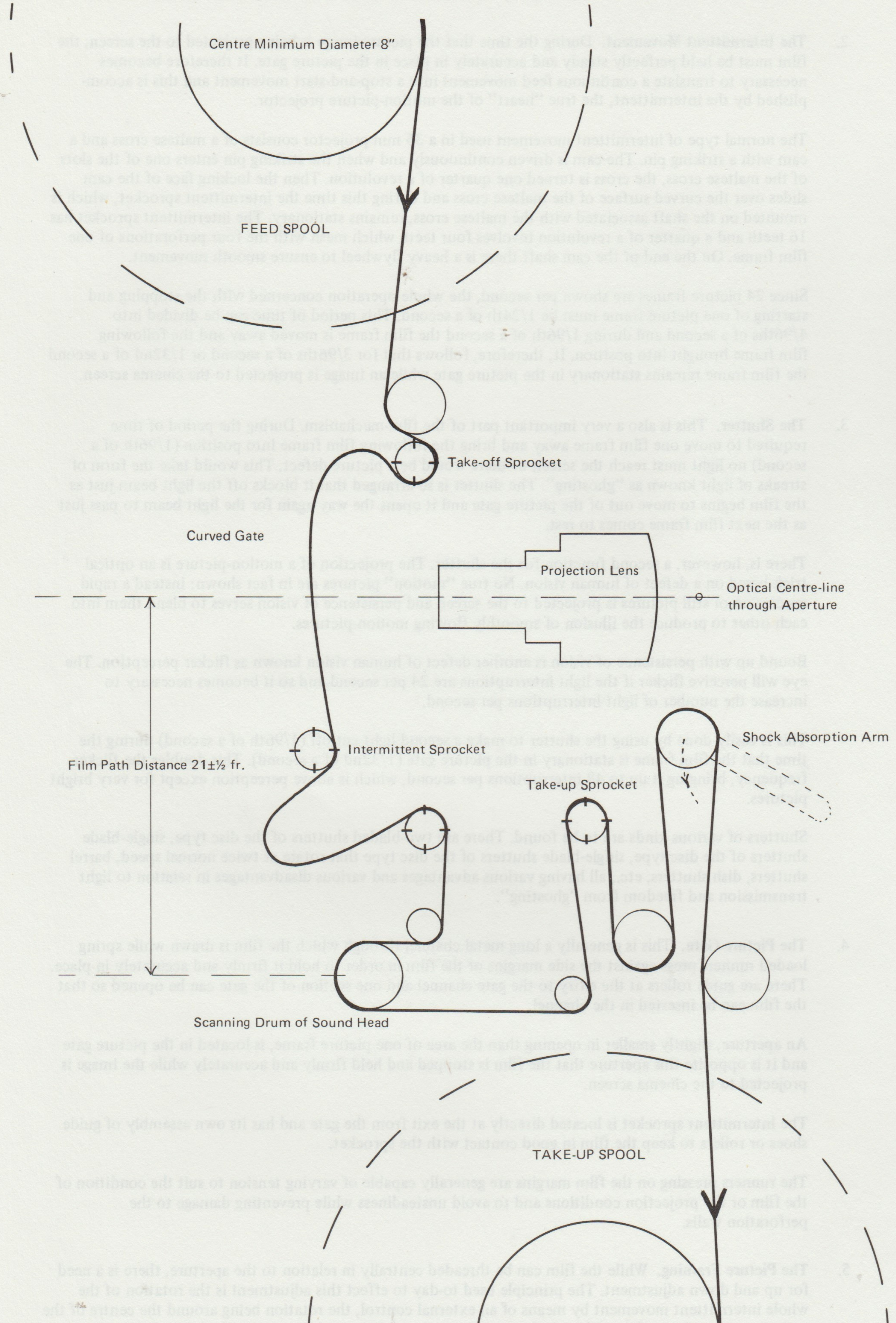
An aperture, slightly smaller in opening than the area of one picture frame, is located in the picture gate and it is opposite this aperture that the film is stopped and held firmly and accurately while the image is projected to the cinema screen.

The intermittent sprocket is located directly at the exit from the gate and has its own assembly of guide shoes or rollers to keep the film in good contact with the sprocket.

The runners pressing on the film margins are generally capable of varying tension to suit the condition of the film or the projection conditions and to avoid unsteadiness while preventing damage to the perforation walls.

5. **The Picture Framing.** While the film can be threaded centrally in relation to the aperture, there is a need for up and down adjustment. The principle used to-day to effect this adjustment is the rotation of the whole intermittent movement by means of an external control, the rotation being around the centre of the maltese cross and sprocket, although the same purpose can be served by moving the intermittent movement vertically.

SCHEMATIC FILM PATH FOR 35mm PROJECTOR (based on Westrex 7000)



6. **The Take-Up Sprocket Assembly.** This consists of a constantly driven sprocket, sometimes known as the bottom feed sprocket, which feeds the film into the bottom spoolbox via the optical soundhead. Associated with this assembly is a system of guides and rollers intended to retain the film snugly on the sprocket with the perforations meshing evenly with the sprocket teeth.

   Between the take-off sprocket and the entry to the picture gate and between the intermittent sprocket and the take-up sprocket there are two film "loops". These are necessary in order to allow for the stopping and starting of the film in the picture gate while the two sprockets rotate continuously. Thus the top "loop" is being enlarged while the film is stationary in the "gate" and the bottom "loop" is being made smaller, and they become equal in size again when the film is moving in the gate.

7. **The Lens Mounting.** This is an integral part of the film-mechanism, although not directly concerned with the passage of film. It is needed, however, to hold the projection-lens in position so that the images of the individual frames may be projected to the screen. This mounting must accommodate various sizes and focal lengths of lenses in a solidly built, accurately aligned, smoothly adjustable assembly, located on the optical centre of the machine.

8. **The Safety Shutter and Changeover Device.** The light source transmits a considerable amount of heat to the film as well as light and while the film is rapidly moving through the light beam no harm is done to it but should the projector stop and the film become stationary in the picture "gate" then the film would blister and smoulder, even though the film is "safety" or "non-flam". To prevent this a safety shutter is always incorporated, which is held open by a centrifugal device while the projector is running, but should it stop or even slow down to a considerable extent, this device allows the safety shutter to drop to protect the film.

   The safety shutter or a similar shutter is also used to make the invisible changeovers from one projector to the other and back. The shutter may be connected to a solenoid or other electro-magnetic mechanism for remote control through a push-button or switch and by suitable interconnection the shutter on one projector can be opened at the exact instant that it is shut on the other projector and vice versa. There is also a variety of manually operated changeover devices available which achieve the same purpose.

d. **The Optical Soundhead.** This is located below the film-mechanism and consists of a series of tension rollers and other damping devices to ensure even and steady movement of the film round the scanning drum between the exciter lamp and the photo-electric cell.

e. **The Bottom Spoolbox.** This consists of a metal box into which an empty spool is inserted onto which the leader of the film is threaded. While the bottom spoolbox is similar to the top spoolbox in general appearance and has a shaft to support the spool, in this case the shaft is not free running. It is power driven by a chain or shaft from the projector motor or has its own motor. A heavier form of friction clutch is inserted between the drive and the spool shaft to compensate for the continually changing speed of spool rotation as the amount of film wound on to the spool increases.

f. **The Stand.** The stand is generally a heavy cast pedestal on which the rest of the units making up a complete motion-picture projector are mounted together. The stand carries a beam on which the carbon-arc lamp or discharge lamp housing can be mounted and from which the bottom spoolbox can be hung.

   The projector stand also has built into it, or in a separate box attached to it, the controls associated with the starting of the projector motor, the switching on of the exciter lamp and the picture and sound changeover. The controls for the projector-arc lamp and its associated rectifier and the ammeter and volt-meter are also generally to be found on the projector stand.

   The projector stand has to be so arranged that the part bearing the arc lamp, film-mechanism, soundheads and spoolboxes can be tilted to throw the beam downwards to the screen, since projection rooms are generally built at the back of the circle well above the screen centre line. These projection rakes may vary from a few degrees upwards to as much as 30 degrees downwards.

g. **The Light Source.** This may be a carbon-arc lamp or a discharge lamp, but in each case the light source is contained in a lamp-housing. This has to be mounted on the projector-stand so that the optical centre of the lamphousing is aligned accurately with the optical centre of the film-mechanism.

   These are the items that go together to make up the modern motion-picture projector and they must not only fit together properly but they must work together efficiently.

   Some of the options available and more detailed information is embodied in further pages of this Manual.

9. PROJECTOR CARE AND MAINTENANCE

There are many different makes and models of projector mechanism in use to-day. Whereas these may differ in a number of characteristics, such as physical appearance, or the way the drive is transmitted from one part of the machine to another and so on, they all do the same job and in a very similar manner.

No piece of running machinery, however well designed and made, can maintain a high standard of performance unless regular attention is paid to its cleanliness, lubrication and proper adjustment, and the cinema projector is no exception to the rule.

It is essential that proper maintenance and observation of projection equipment is carried out regularly. An established routine in these matters is recommended.

In this Section it is proposed to cover the maintenance of projectors, drawing special attention to one or two salient features.

The first consideration must be with respect to the film path; this includes all parts of the mechanism which transport and actually come into contact with the film when in motion.

These can be summarised as follows:

The top spoolbox and "firetrap" with spindle assembly.

The top sprocket and roller assembly.

The projection gate, pressure pads and aperture plate.

The intermittent sprocket and shoe.

The lower-line sprocket and roller assembly.

Any guide or entry roller assembly to the soundhead which may be mounted as part of the projector.

The lower spoolbox and take-up assembly.

Many sound servicing contracts include the responsibility for maintenance of some of these items but it is undoubtedly the responsibility of the projectionist to see that these parts are kept clean and in proper adjustment.

The top spoolbox take-off spindle is usually mounted in a long sleeve bearing, and it should be removed about once a week, the bearing cleaned, inspected and a spot or two of fresh oil applied through the oiling hole, seeing it come through the bearing. Wipe the old oil from the spindle and the clutch disc, lubricate lightly and re-assemble with the necessary tension to check spool overrun without strain.

Similar treatment should be given to the lower spoolbox take-up assembly, together with the take-up drive, whether belt or chain driven. The old idea, which is still subscribed to by some projectionists, of leaving the take-up strictly alone "while it is working O.K." does not pay dividends in the long run, but often leads to sudden failure of a component, when it is then, frequently, too badly worn to be capable of any adjustment. The better way is, of course, to learn to understand the correct condition and tension required, and to keep it that way by regular attention. It can be stated in principle that the correct tension required is that which will take up a full spool of film with neither slip nor strain. A word of warning: most spoolbox spindle assemblies include a locating device such as one or more Woodruffe keys; take care not to drop or mislay these, and avoid damaging them when dismantling or assembling.

All film runners, such as the projection gate fixed runners, etc., should be kept free of any deposits and preferably should be wiped after every reel. Watch for wear resulting in the distortion of contours.

The film projection gate pressure pads, or skates, must be watched for worn contours and should always be adjusted to the minimum tension necessary to ensure a steady picture with the particular film stock in use at the time.

For roller assemblies, it is only necessary to offer the following advice:

Keep all rollers free to rotate with a light touch from the moving film.

Do not allow any roller to develop "flats" or other surface distortions.

Never allow emulsion from the film to build-up on the roller surfaces or flanges.

Film retaining roller assemblies should be adjusted so that there is exactly two film thicknesses space between the retaining roller and its associated sprocket. The method used for adjustment is usually obvious. The film lateral guide half-rollers at the top of the projection gate must especially be watched for undue wear, and care should be taken that they are always adjusted correctly to perform the function for which they are designed. In the usual arrangement, the outside half-roller is a controlled position roller, which must be set to guide the film correctly into the gate in its proper path. The inside half-roller is controlled laterlly by a coil spring and should keep a light pressure on the other film edge.

All sprockets should be cleaned and examined regularly. A special sprocket brush, or a good stiff tooth-brush, should be used to keep the spaces between the teeth free of emulsion. In the case of the intermittent sprocket, see that the gate sprocket shoe is correctly adjusted to give two film thicknesses clearance from the sprocket film surfaces; never allow the shoe to press against the sprocket.

The method of lubrication adopted for film projector mechanisms usually comes under one of the two headings below:

a. Hand charged gravity feed systems.

b. Automatic oil-pump distribution of oil.

The first named classification frequently employs a pipe system to convey the oil to each point requiring lubrication. This system is fed either from a common reservoir situated at the top of the mechanism frame, or from a number of separate oil cups conveniently situated for their purpose. When separate oiling points are provided it is suggested:

A few drops of oil in each bearing daily.

A few drops on any vertical or horizontal shaft daily, taking care that lubrication is provided to any actuating movement which has to travel on any shaft.

Move the framing adjustment up and down a few times whilst oiling.

With the framing adjustment at the centre position, see that the intermittent unit is filled with oil to the correct level on the gauge usually provided.

The type of mechanism requiring manual lubrication is generally fitted with an easily removable rear cover or door, making possible the frequent inspection of the interior.

With the pump-type mechanism (b), providing that the oiling system is clear and the oil level maintained correctly, the lubrication of all parts of the system should be carried out quite automatically. The oil in the pump and sump area should be drained off and fresh oil provided at regular intervals. Filler and drain plugs are provided to facilitate this work. The frequency with which this oil change is necessary is dependent mainly on running hours, but it is suggested that a routine is established and kept, based closely on the recommendations of the manufacturer.

Many pump type mechanisms are fitted with both fine metallic gauze filters and magnetic filters, the functions of which are to remove all foreign matter from the oil, the magnets collecting any small particles of iron or steel. Whenever an oil change is made these filters should be removed and cleaned, taking care to see that all metal particles are removed from the small magnets, where these exist.

Exceptional wear and tear of parts of the mechanism drive can often be detected at an early stage by intelligent examination of the condition of oil, when it is drained-off, and inspection of particles in the filters.

When replacing covers, drain or filler plugs, etc., on this type of mechanism make sure that all gaskets, oil seals, washers, etc. are replaced correctly and are undamaged.

Some projector mechanisms employ so-called self-lubricating bearings, which require only such little attention as the makers suggest. The actual oiling on this type of machine is usually restricted to a few points where the special type bearing is not justified.

If it is necessary at any time to remove or replace any gear or other part of the projector mechanism, other than the normal parts that have to be removed for regular cleaning and servicing, it is advisable to obtain and follow the specialised instructions of the manufacturer. Most suppliers will quote for work that is beyond the scope or experience of the projectionist, and will provide skilled engineers to carry it out.

Where an electrical changeover system is incorporated, the actuating linkage will require regular attention.

Whenever a projectionist takes over a new or strange projection equipment, he should make an early point of acquainting himself fully with both sides of his machines, as the understanding and proper maintenance is as important as the operation of them.

It is quite as important to maintain a high standard of cleanliness and efficiency in the soundhead, and many of the foregoing observations are equally applicable to the components of the film path therein. Particular care must be taken, however, not to interfere with the adjustments of the optical systems in optical soundheads.

When cleaning magnetic soundheads, on no account should the position or adjustment of the magnetic scanning heads be interferred with. It must also be emphasised that all tools used in, or in the vicinity of, the magnetic soundheads should be properly de-magnetised, or be of non-magnetic materials.

The care of lenses used on projection apparatus is dealt with elsewhere in this book, so has not been touched upon here.

Lastly, as is the case in the use of all types of running machinery, there are a few important and necessary "don'ts" to which it is felt essential to draw attention.

Never attempt to wipe down or touch a machine with a duster or other rag whilst the machine is running. A surprisingly large number of projector mechanisms have come to grief as a result of the wrapping-up of a duster in the drive or sprockets, invariably resulting from obvious neglect of this precaution.

It is inadvisable for projectionists to attempt any work or adjustment to the internals of the intermittent unit of a film projector. In any case, hardly any theatres are equipped with the necessary facilities for carrying out such work to the fine limits demanded. Therefore, the advice is, DON'T, under any circumstances, open up or tamper with this piece of precision apparatus. In the event of maladjustment or failure of an intermittent unit, get into immediate touch with the nearest branch or agent of the manufacturer, who will make early arrangements for the repair or replacement of the part.

The practice of over-oiling a projector mechanism can be nearly as dangerous to the proper performance of the equipment as under-oiling. Excess oil has an almost uncanny way of infiltrating into every part of the soundhead, especially the optical assembly, into the windings of the projector drive motor, and much of the machine wiring may become impregnated with it. It needs little use of the imagination to visualise the probable results of the effects of such occurrences upon the film. Therefore, always oil with discretion and always immediately remove any excess oil.

10. THE MEASUREMENT OF PROJECTOR PERFORMANCE

To secure consistently good presentation the equipment in the projection box, the screen and the loudspeakers must all be maintained to a high degree of efficience. The human eye and ear are not sufficiently reliable and do not easily detect a gradual deterioration in performance.

For these reasons the accurate measurement of the various functions of a projector is important and instruments have been devised and standards recommended to enable a consistent high level of performance to be attained. These means are:

1. B.S.I. standard specifications, especially
   BS 5550:7.2.3:1978 for Screen Luminance
   BS 1985-1953 for 35mm optical sound test films
   and BS 5550:7.4.1:1978 for overall electro-acoustic response
2. Meters to measure screen luminance and sound output
3. Test films for both picture and sound

It is unlikely that a complete range of test films and instruments will be available in individual theatres but service departments and circuit engineers should have them. It is important that checks be made on a regular basis.

Picture Performance

There are various methods of measuring the light output of the different sources illuminating the screen and units for expressing these measurements, but the important measurement for the projectionist is the light **reflected** from the screen, the screen luminance, and this is expressed in foot-lamberts. This measurement should be made with a spot brightness meter so that not only can the projectors be balanced but the variation of brightness from centre to edge and from centre to corners of the screen can also be measured.

Standard practice specifies the use of a spot photometer with a narrow acceptance angle, preferably 1½^{o} and not greater than 2^{o}, used at a position two-thirds of the distance from the screen to the back row of seats. From a distance of say 15 m the measured spot on the screen would be approximately 0.5 m in diameter. Readings should be taken of the luminance of the centre of the screen and in at least two positions at the sides 10% of the screen width inside the edges of the masking.

The use of a normal photographic exposure meter to measure the light falling **upon** the screen is not recommended. It is a very rough and ready improvisation which will merely indicate whether the light output from the projector is remaining constant from one occasion to another. Since it takes no account of the relectivity of the screen and its condition, it cannot give a genuine screen luminance value.

Test films are available to examine travel ghost resulting from intermittent wear or shutter mis-adjustment, image steadiness in terms of jump and weave, focus, alignment and aperture size and position. Such tests do not require instruments to assess the results: critical observation by a skilled projectionist will give all the information required on projector performance. The clearly defined patterns on these test films will also show up very distinctly such faults as dust or oily marks on the projector lens and port glasses.

Sound Performance

The maintenance of consistently high quality sound reproduction can only be attained by the use of test films in combination with the appropriate test instruments. The position of the film sound track in relation to the sound head optics, their focussing and azimuth adjustment are all critical and the mechanical condition of the equipment to produce minimum wow and flutter must be maintained. The frequency response and output level from each projector must be measured and balanced so that there is no obvious change of sound quality when changing-over from one to the other.

The complete assessment of the overall electro-acoustic response of a motion picture theatre, as specified in BS 5550:7.4.1:1978, requires the use of more elaborate equipment and techniques of interpretation and is therefore outside the scope of routine tests on projection performance. Such complete measurements should however be undertaken by the appropriate servicing organisation whenever major building alterations are made to an auditorium or when a completely new sound system has been installed in an existing theatre.

Picture and sound test films and their use are described in the following pages of Section 11 and the published British Standards applicable to film presentation are listed in Section 43.

11. TEST FILMS FOR PROJECTORS

A competent projectionist is generally able to judge whether his equipment is functioning properly by careful observation of the picture on the screen and by listening to the audio output. However, if the circumstances change then relying on experience and the reproduction of everyday programme films can become inadequate. If new equipment is installed or if a slow deterioration has taken place or if a faulty film is being shown – these factors can upset a judgement based on merely maintaining the status quo. It is then that a Test film, specially made to a known standard, becomes of value because it provides an absolute quality reference. It is therefore good practice to hold appropriate Test films and to project them periodically or when a particular need arises to check the equipment.

Picture Test Films

The two main parameters to be checked as regards the Picture are "Sharpness (i.e. Resolution)" and "Steadiness" and test films are available for this purpose.

The "Sharpness" Test films are themselves of very high resolution and contain areas of fine lines or dots. When projected and viewed closely the limiting sharpness of the projector can readily be assessed. Deterioration of sharpness due to dirty or scratched lenses or glass ports is detectable. Further more any unevenness of sharpness over the picture area is shown clearly, revealing misalignment of the projector gate, film positioning, incorrect pressure pad adjustment, etc.

For critical assessment of the whole optical performance, a test film having definition charts showing various numbers of lines per millimetre on the image is necessary. The finest pattern which can be focussed in the centre of the screen should be observed: a good projection system in good clean condition should be able to resolve at least a pattern of 48 lines per millimetre on the film.

The "Steadiness" Test film is itself printed and perforated to the highest possible accuracy and therefore when projected the resulting picture identifies any unsteadiness due to the projector. Picture unsteadiness, such as weave, hop, jump – regular or intermittent – has many possible causes but at least it can be shown to be present by a Test film. Hopefully it can eventually be shown to be cured.

When projecting a Steadiness test it is useful to have a solid object, such as a microphone or music stand, on the stage in front of the screen to cast a fixed shadow on the projected image. Measuring the movement between image and shadow will allow vertical unsteadiness to be expressed as a percentage of the total screen width: 0.25% can be regarded as a respectable standard.

The other Picture Test film of value, particularly in new or modified installations, is one showing the standard picture sizes and areas. These can be quite complex with the different Academy, Widescreen and Anamorphic standards and a calibrated test film allows the screen masking to be adjusted with confidence to the standard position.

The same test film serves to check the correct alignment of projector to screen for both machines, so as to minimise any jump at change-over, and to assess the effect of horizontal and vertical projection angle causing keystone type distortion.

The three tests – Sharpness, Steadiness and projected image Size – are often combined in one film and the lists published by the British Kinematograph Sound and Television Society and the Society of Motion Picture and Television Engineers, as well as the maker's data sheets, should be consulted for details of those currently available.

All these picture tests are visual image tests to be assessed by the human eye – no special measuring equipment is required, only the test film itself. When using them, it is not good practice to make them up in short continuous loops for viewing, however convenient this may seem. The heat of the projector light source can rapidly cause distortion on constantly repeated film and seriously affect its performance in the gate. Prints of test films should always be kept wound on a large diameter (75mm or 3") plastic core or on a large hub spool and stored in a sealed can in a cool place.

With careful handling, Test Films will function properly for many passes through the projector but eventually they will become worn and will cease to be a valid standard by which performance can be judged. Worn perforations, buckled film, severe scratching will lead to poor assessment and when these features become noticeable the film should be replaced.

Optical Sound Test Films

The sound reproducing chain needs to be checked frequently by running Test films for such characteristics as "Frequency Response", "Flutter and Wow" and "Distortion". Audio test gear is also essential for some of these tests and the correction of faults as described in Section 27, Keeping an Eye on the Sound, in this Manual.

Before the frequency response can be measured in detail it is necessary to check that the sound slit in the projector is properly focussed and at the correct angle, with respect to the film. For this purpose a "Focus and Azimuth" Test film is used. This film carries a continuous high frequency tone (approx 7000 Hz) which is recorded very accuractly at the correct azimuth, i.e. at right angles to the film edge. Focus and azimuth adjustment is then made by setting for maximum output level which can be judged by ear or by output meter.

The "Frequency Response" test film carries a wide range of sound frequencies from the lowest to the highest capable of reproduction on conventional equipment. These should ideally all be reproduced at the same single level and some form of output meter is necessary to measure this.

The "Flutter and Wow" test film carries a continuous tone of about 3000 Hz which has been carefully made to have a very constant pitch. Any fluctuations in the film velocity over the sound head will thus cause the reproduced pitch to vary. Such variation is clearly audible and readily assessed by ear but if measurements are required a special Meter is required which is calibrated in percentage departure from normal velocity. These variations may be fast or slow and are known as Flutter or Wow respectively.

A common cause of Distortion on sound is lateral misplacement of the sound slit in the projector and a "Buzz Track" test film allows this to be checked very simply. The film has no sound recorded in the proper sound track area but just outside this area there is a recording – high frequency on one side and low on the other. If either tone is audible this indicates a positional error and the sound head should be adjusted for no audible output.

Another cause of distortion is uneven illumination of the slit. This fault is detected by the "Scanning Beam" test film (often known as a "Snake" film) which contains a thin strip of sound track which progressively moves from one side of the proper sound track area to the other. Any variation in the illumination across the slit is revealed by a variation in the sound output level. Sometimes the position of the strip is illustrated in the picture part of the film so that the location of a fault is easily identified.

12. LONG PLAYING SYSTEMS

Undoubtedly one of the most important changes during the last few years, affecting both projection room equipment and film handling practice, has been the increasing use of rolls of film considerably longer than the earlier standard of 600 m (2000 ft) maximum. Most modern projectors are supplied to take spools of 1800 m capacity (6000 ft), so that only one change-over is necessary in the course of a complete feature film show and many indeed can operate with 4000 m spools (13,000 ft), so that a show up to some 2½ hours duration can be run from a single machine without a pause. Where such projectors incorporate automatic rewinding, a pair of machines allows a total programme up to 5 hours to be shown without a break and repeated as many times as required without ever removing the film from its projection spools.

In many theatres, however, the original machines designed for 600 m reels are still in use and for these a number of free-standing long-playing devices have been manufactured which can be installed at the rear of the projector to handle the large reel assemblies, the film passing over an open path with supplementary rollers to and from the main projector head.

Two main systems are in general use:

1. The outboard reel carrier or tower unit, with two 4000 m spool positions one above the other, each spool spindle having its own motor drive controlling both feed and take-up tension and providing motorised rewinding at the end of the run.

2. The platter or "cake-stand" system which eliminates rewinding. In this arrangement the roll of film, which may be up to 7500 m (24,500 ft) giving some 4½ hours playing time, is carried on a large horizontal motor-driven turntable as an open roll without any spool. The film feeds from the centre of the roll over guide rolls to the projector and returns along a similar path to be taken up on a second turntable disc. Since the diameter of the roll varies greatly from the beginning to the end, the rate of rotation of the turntable motor is automatically controlled by tension arms on the film path.

   By the end of the programme the whole film has been wound up on the second disc, which now becomes the feed, and the projectionist can rethread the film through the feed path to the projector head and back to take up on the first turntable. Since no rewinding is necessary, this replacing need only take a few minutes before the whole programme is ready to be repeated in full.

   A third platter disc is usually provided so that the make-up or break-down of another complete programme can be carried out even while a show is actually being run from the other two turntables. A make-up table taking the film as received from the exchange gives exact control of the third platter speed and the feed spool in both directions of rewinding. A complete made-up roll can also be transferred from one turntable to another without going through the projector path.

Details of some of the commercially available systems are given below:

1. Outboard Reel Carriers or Towers

Westrex 5035

This unit carries two pairs of 4000 m spool positions, so that one pair can be used for rewinding or make-up and break-down while the other pair is in use as projector feed and take-up. The whole unit is mounted on a turntable, so that at the end of a programme the next pair of spools can be brought into line with the film path to the projector and threaded-up with a minimum of delay.

The 12.5 mm diameter spool spindles are each driven from a 200 oz-inch (1.4 Nm) torque motor through a 2:1 step-down toothed rubber belt. A motor control circuit ensures that both take-up and feed motors are energised before the main projector motor is switched on so that any film slack in the path is taken up to prevent snatch and the run-up time is monitored to give a smooth start. A safety device can be fitted so that in the event of a film break the power supply to both projector and carrier is switched off.

Rewind and make-up speed on the pair not in use for projection is manually controlled but the recommended time for rewinding a full roll of 4000 m is not less than 15 minutes.

Overall Dimensions with 4000 m spools (91 cm in diameter):

2.11 m high, 0.92 m wide, 0.53 m deep; turning circle 1.17 m, weight 213 kg.

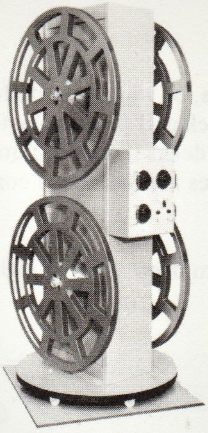


Fig.1. Westrex 5035 Film Carrier Assembly.

Wassmann 4000

This unit has one pair of 4000 m spool positions only; the lower take-up spindle is motor-driven through a friction system and the feed is automatically braked to constant tension. On rewinding, the lower friction is disconnected and the upper reel driven by a DC motor with manual control, having a maximum speed of 4000 m in 10 minutes. A "soft-start" projector control is provided and automatic electro-magnetic brakes come into operation if the film should part.

Dimensions: 1.95 m high, 0.92 m wide, 0.45 m deep.

Cinemeccanica DGB

This is available in two models, DGB 2 x 4, for one pair of 4000 m spools, and the double-sided DGB 4 x 4, which has two pairs and can be rotated on its vertical axis so that either side can be rewound while the other is feeding the projector. In both, the take-up speed is self-correcting, being controlled by the weight of the film on the spool, Inertia-compensated take-up spools are available as an added precaution against film snatch on start-up. The rewind time for a full spool is 12 minutes and an automatic device can be fittted to shut off the rewind motor when a spool has been completely rewound.

Dimensions (of DGB 4 x 4): Overall height 1.91 m, spool overall width 1.00 m, depth 0.62 m, turning circle 1.19 m.

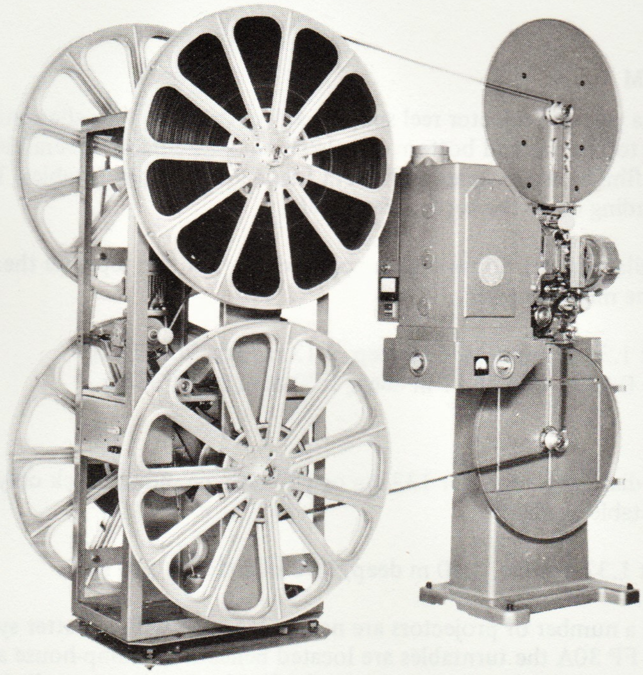


Fig.2. DGB 4 x 4 Long Playing Tower, shown here coupled to a Cinemeccanica Victoria IV Projector.

2. Platter Systems

Philips Non-rewind LP Unit

This has three 120 cm (47") diameter turntables, of which the middle deck is normally used for make-up and break-down. There is independent levelling of each deck and the automatic feed and take-up speed controls have manual over-ride and a safety stop of the projector and decks if the film breaks. The make-up table takes a feed spool up to 1800 m capacity mounted vertically and provides manual speed control of both this and the make-up deck in both winding directions.

Dimensions: Turntable unit 1.35 m wide, 1.50 m deep, 1.85 m high. Weight 160 kg.

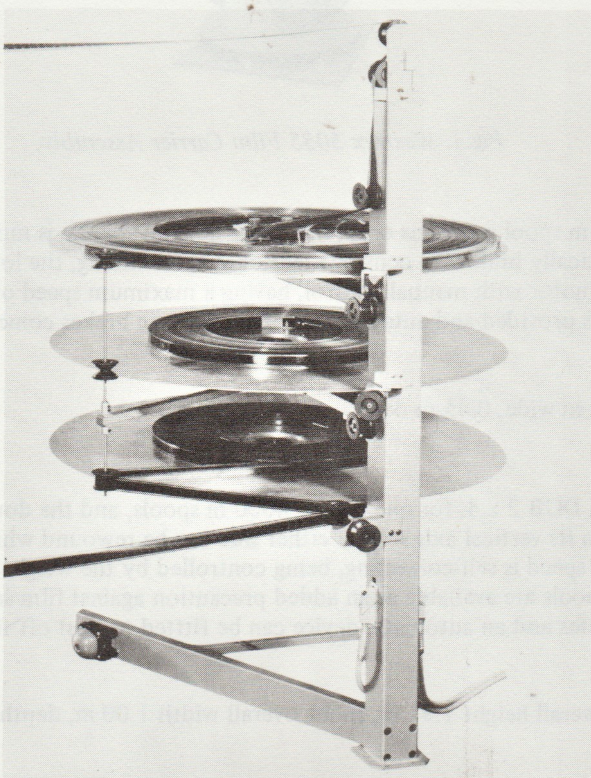


Fig.3. Philips Non-rewind Long Play Unit.

Christie Autowind AW2-AFM

Three 132 cm platters with a pair of projector reel support arms; normally only the centre deck is used for make-up but as an optional extra the top or top and bottom can also be made available. Overall levelling by adjustable feet. There is a safety stop if the film breaks or tears and direct transfer between turntables. The make-up table has a DC motor for braking and rewinding on to the vertical feed reel.

The Autowind AW4 is a similar unit with four 132 cm platters, so that two separate theatre systems can be run from the same equipment with one make-up table.

Dimensions: Turntable Unit 1.32 m wide, 1.50 m deep, 2.13 m high. Wt 227 kg
Make-up Table 0.68 m wide, 0.51 m deep, 1.20 m high. Wt 33 kg

Ernowind

A three turntable unit with diameters of either 132 cm or 124 cm; the middle deck only used for make-up. Usual safety devices and make-up table available.

Dimensions: Turntable Unit 1.32 m wide, 1.50 m deep, 1.92 m high. Wt 140 kg

It is interesting to note that a number of projectors are now being built with a platter system of feed and take-up incorporated. In the Philips FP 30A the turntables are located beneath the lamp-house and can be provided in diameters of either 102 cm or 124 cm; normally only two decks for feed and take-up are supplied, but a third for make-up can be fitted if required, although space is limited. Since the projector may often have to be installed in an inclined position, the turntables can be independently levelled.

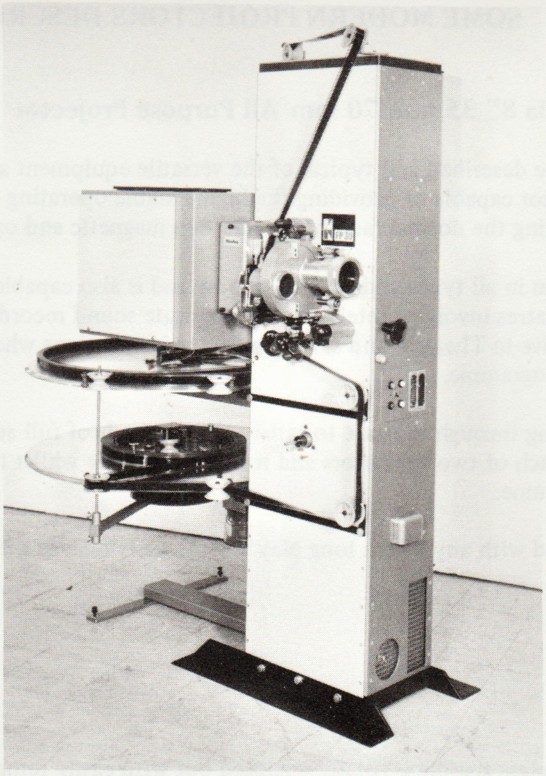


Fig.4. Philips FP 30A Projector incorporating non- rewind long play unit.

The Bauer U6 is another projector with the film carried on horizontal turntables below the lamphouse; however, this is not a non-rewind system as the film is fed and taken up on the outside of the roll in the conventional way and it is necessary to rewind at the end of the programme from one deck to the other. But the horizontal mounting allows film rolls up to 4800 m to be handled, giving 3½ hours running, without spools if necessary, and with direct make-up onto the projector turntable. The feed and take-up turntable drive motors are controlled by the film tension, which is kept low, and high speed rewinding allows a complete feature film to be rewound in about 10 minutes.

13. SOME MODERN PROJECTORS DESCRIBED

The Cinemeccanica "Victoria 8" 35 mm/70 mm All Purpose Projector

Several modern projectors will be described and typical of the versatile equipment available is the Cinemeccanica "Victoria 8" All Purpose Projector capable of providing the highly stable operating conditions demanded for 70 mm sound film projection and retaining the normal facilities for 35 mm magnetic and optical prints.

It provides first class presentation in all types and sizes of cinema and is also capable of handling the special requirements of studio and preview theatres involving interlock with separate sound recording and reproducing systems and the exacting requirements of Drive-in Theatres and single projector installations where continuous operation is needed for the whole duration of the programme.

It is available with reverse running through the gate to satisfy the demands of full automation. Loaded with up to 13,000 feet of 35 mm film on each of two projectors and rewinding on one whilst the other is projecting it provides approximately 4¾ hours programme.

A single "Victoria 8" can be used with any of the long play attachments such as the Cinemeccanica 4 x 4 tower and is an extremely versatile projector.

Technical Details

Mechanism

Driven by toothed belt, the noiseless gearing is totally enclosed but with easily removable rear cover. Film transport is by two constant speed sprockets (a third is fitted but only needed when a magnetic soundhead is in use). In the 35 mm/70 mm version these sprockets have a double profile to make them suitable for both widths of film and the lay-on or pressure rollers are instantaneously reversible to suit either film.

Intermittent Unit

The Maltese Cross and Cam assembly is oil immersed. The movement turns the intermittent sprocket 90^{o} allowing the maximum acceleration possible consistent with avoiding film damage. The 35 mm/70 mm sprocket also has a double profile 16T/20T. Framing adjustment is by rotating the complete assembly in an arc around its driving gear.

Picture Gate

This is curved with 4 pads for film tension adjustment. Separate readily interchangeable gates are supplied for 35 mm and 70 mm film. 35 mm mask plates slide horizontally giving a choice of three apertures. An independent blower gives direct air cooling of film in the gate. Provision is also made for water circulation from separate source.

Masking Shutter

A two bladed conical shutter is provided giving maximum light efficiency.

Safety Shutter

This is fitted between the light source and the conical shutter and operates automatically if the film breaks. It is also used for sound and picture cyange over between projectors. It can be fitted with a solenoid for automation.

Lens Holders

For 70 mm operation it is usual to supply a single lens holder with a diameter of 127 mm so as to accommodate the normal 70 mm projection lens, with pre-focus adapters for 35 mm lenses of lesser diameter. For 35 mm operation only, a three lens turret can be supplied accommodating one 70.6 mm diameter and two 62.5 mm diameter lenses. Focusing of individual lenses is carried out by micrometric adjustment (motorised 2 lens and 3 lens turrets can be fitted with remote focus drive and special provision can be made for introducing a separately held anamorphic lens).

Optical Soundhead

This is mounted directly on the projector. It comprises a rotating drum with magnetically stabilised flywheel and PE Cell or Photo Diode fitted inside the drum. Film drive is provided by the lower sprocket and an oil damper is fitted. The prefocused exciter lamp is separately housed with adjustable optical system.

Magnetic Soundhead

A magnetic soundhead can be mounted on the front of the projector casing and also carries a stabilising drum and flywheel. Film drive is provided between the two upper sprockets and an oil damper is fitted. The magnetic cluster can be a reversible 4/6 Track for 35 mm/70 mm or a 4 Track for 35 mm only. Where necessary single track heads can also be supplied and all heads can be made in a plug-in version for easy interchange.

Lubrication

This is by oil sump and gear pump distributing oil to all parts including the intermittent unit (which has its own level indicator). Filters are fitted and oil flow and oil sump level windows give a positive indication that circulation is complete.

Driving Motor

This is normally a 3 phase low voltage 50 cycle motor with inching knob. It drives by toothed belt and for 35 mm/ 70 mm operation has a reversible toothed pulley giving the necessary speed change.

Stands

Two versions are available resulting in slightly different optical centres but what is known as the cinerama stand is mainly used when 13,000 ft spool accommodation is required. Both standards house in their columns and lamphouse beams such items as connecting blocks, exciter supply units, safety devices and motor starting gear together with the complete wiring, switching and fuses. Tilting adjustment for rake is from 5^{o} positive to 18^{o} negative.

Film Take-Up

This is toothed belt driven and for 1800 m spools comprises the normal adjustable spring loaded clutch. For all 3000 m and 4000 m spools there is a weight-actuated self-compensating cone drive which coupled with an upper loop absorber provides constant film tension under all conditions.

Lamphouse Accommodation

The standard lamphouse beam can be fitted with adjustable support to suit almost any type of arc lamp or Xenon lamphouse.

Safety Device

A mascarini Safety Device is available for fitting to all models. This device in conjunction with a lower safety roller and various micro-switches on the projector and lamphouse will shut down the projector completely in the event of film break or mechanical or electrical failure and will reduce the risk of operator error in handling.

Film Accommodation

The versatility of this equipment is clearly seen in the variety of options available:—

1800 m spools on the projector with or without boxes (Victoria 8)
3000 m spools on the projector with or without boxes (Victoria 8)
4000 m spools on the projector with or without boxes (Victoria 8)
4000 m and 1800 m spools on the machine with or without boxes (Victoria 18)
4000 m and 3000 m spools on the machine the former with or without boxes, the latter being open spools (Victoria 18)

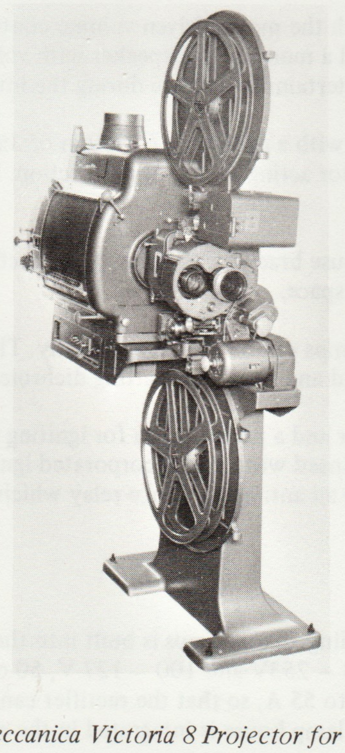


Fig.1. The Cinemeccanica Victoria 8 Projector for 35mm and 70mm.

Other Cinemeccanica Projectors

While the Victoria 8 is of interest as a combination 35/70 mm machine, with optical and magnetic sound facilities, other models in the Cinemeccanica series are specifically for 35 mm use with optical sound only. The Victoria 9, which has superseded the earlier Victoria IV, embodies a straight picture gate, rather than the curved path of the Victoria 8, and the drive is by continuously lubricated gear train. The lens mounts can be single lens-holder or a manual or automatic-change 3-lens turret. It can be fitted with a choice of 1800 m or 3000 m capacity spools and is also available mounted on an open girder stand for permanent use with a long-play tower feed.

The versatile Victoria 5 series is also available in several forms to cover a range of 35 mm requirements with optical sound. The drive is by belt-driven gear train with nylon gears in some positions; the intermittent is a sealed oil-filled unit and the rest of the machine is effectively dry, requiring practically no oil replenishment. The basic Victoria 5 has open spool plates for 1800 m and can be extended to take 3000 m, while the heavy duty Victoria 5S is built to take spools up to 4000 m with covers, as well as mount the largest types of lamp-house. The Victoria 5MI incorporates forward and reverse winding and is designed for fully automatic operation.

For installations where overall height of room is a limitation preventing the use of large upper feed spools, a special version, the Victoria 5B, carries both 4000 m spools below the projector and is equipped with an additional built-in variable speed rewind motor, so that a complete programme can be made-up on the machine.

A portable adaptation, Victoria 5P, contains a complete compact transitorised sound system C/55PT and can be fitted with either a 400 W halogen incandescent lamp with its own transformer or a 500 W xenon. The whole unit may be mounted on its own carrying case as a pedestal or on a trolley for even greater mobility.

The Philips 35 mm Projector FP 30

The FP 30 Projector is another modern equipment for medium sized Cinemas which is typical of the most recent approach to completely integrated projection engineering. It is rack-mounted and the equipment necessary for the film transport is mounted on interchangeable panels at the front of the rack. The projector can be arranged for 600 m, 1800 m and 3500 m film spools, or for non-rewind devices, Fig. 3.

A lens turret for two 70.6 mm lenses, Fig. 4. can be operated by hand but it may be motor-driven and equipped with an automatic mask changer as well as with remote control for focusing and framing.

At the side opposite the transport mechanism there is a hinged rack frame holding the electrical unit, Fig. 5. A universal transformer allows the equipment to be connected to the mains of either 220 V or 110 V $\pm$ 10%, 50 or 60 Hz. An exciter lamp supply unit, plug-in relays for the picture and sound changeover, and an automatic circuit breaker which can disconnect the entire installation from the mains are included. One or two fully transistorized Philips amplifiers are built into the projector housing and can easily be replaced.

The hinged rack frame contains a panel with the motor-driven volume control with two control units, a mono-stereo switch, an amplifier change-over switch and a monitor loudspeaker with volume control. Another panel is equipped with a cassette tape player for entertainment music during the interval.

If the projector is intended for film spools with a capacity of 3500 m of 35 mm film, rewinding from the lower to the upper film spool is brought about by a motor acting on the upper friction. Hence there is no need to purchase a separate rewinder or reel carrier.

The Xenon lamp-house requires no lamphouse bracket and is flanged directly on to the housing of the projector. With a length of 50 cm this solution saves much space.

Either 700 W, 1000 W or 1600 W xenon lamps can be used horizontally. The lamp house contains an elliptical mirror with a diameter of 28 cm; both silver-coated and heat-transmitting dichroic-coated mirrors are available.

In addition to an ammeter, an hour counter and a press button for igniting the lamp, the lamp house contains three ventilators. A chimney can usually be dispensed with. The incorporated ignition device is now normally provided with an automatic ignition pulse repeat unit and an anti-interference relay which shorts the loudspeakers during ignition.

Built-In Xenon Lamp Rectifier

In the FP 30 projector the rectifier for feeding xenon lamps is built into the lower part of the projector housing. Single-phase connection to mains from 198 – 253V and 100 – 127 V, 50 or 60 Hz, is possible. The direct current can be continuously controlled from 20 A to 55 A, so that the rectifier can feed either 500 W, 700 W, or 1000 W lamps. The wiring of the projector and the lamp house is integrated in the equipment.

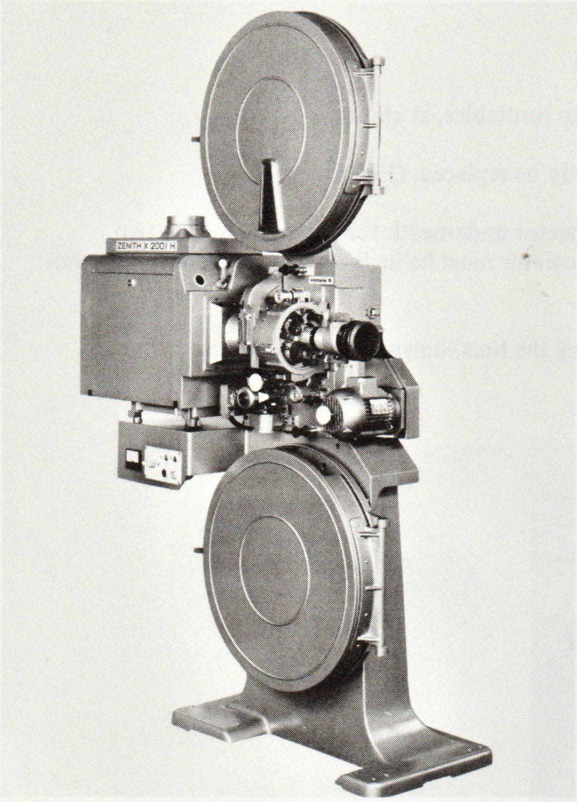


Fig.2. The Victoria 5S Projector for 35mm.

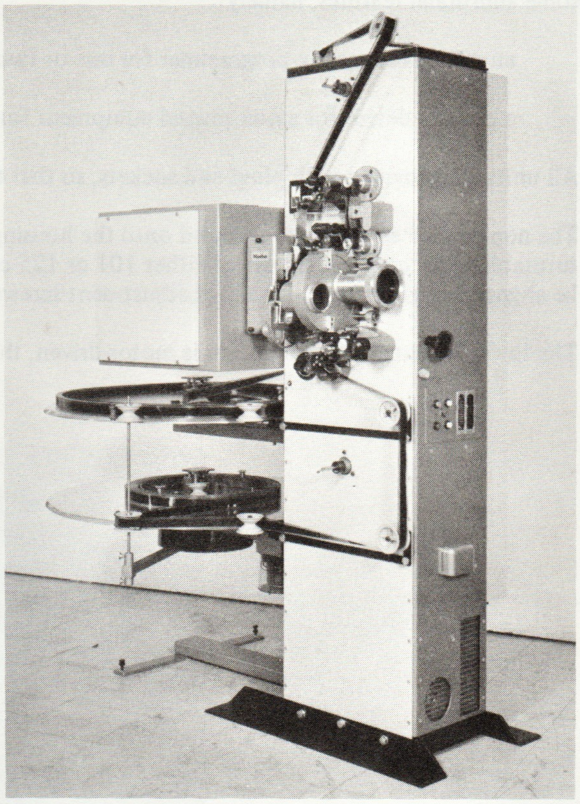


Fig.3. The Philips 35mm Projector FP30.

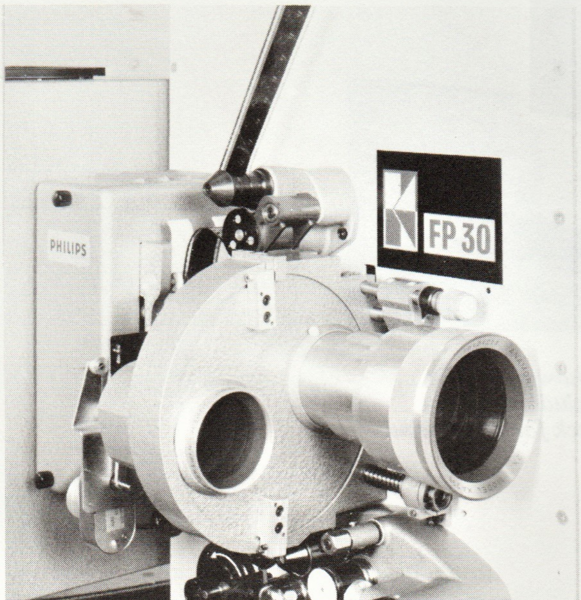


Fig.4. Two-lens Turret on the FP30 Projector.

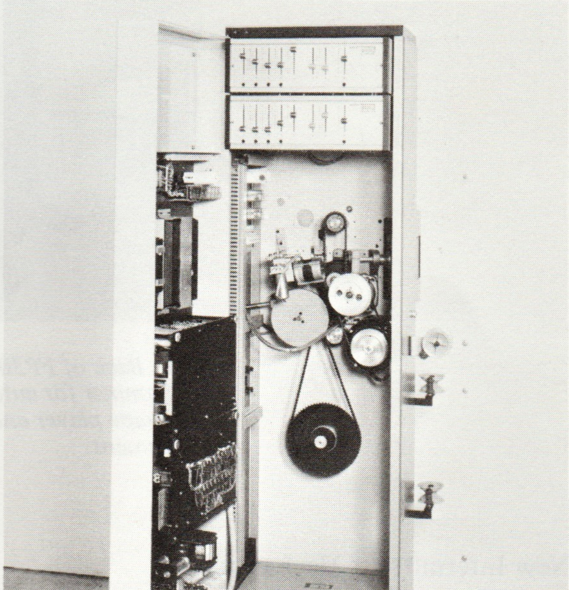


Fig.5. Interior of FP30 Projector showing hinged rack holding electrical unit. Built-in rectifier in the base.

35 mm Projector FP 30 A

The design and accessories of the FP 30 A version correspond to those of the projector FP 30. However, it contains some additional features, namely:

an automatic matrix-programmer for one or two projectors;

a control device for a non-rewind equipment for two or three turntables, at choice.

All units are provided with plugs and sockets, so that they can easily be replaced. (Fig. 6)

The non-rewind equipment is flanged onto the housing of the projector underneath the lamp house. The two turntables may have a diameter of either 101 or 125 cm. If the projector must be inclined, the turntable planes can be aligned horizontally by means of adjustment screws.

The lower friction of the projector is motor-driven, thus facilitating the breakdown of the programme.

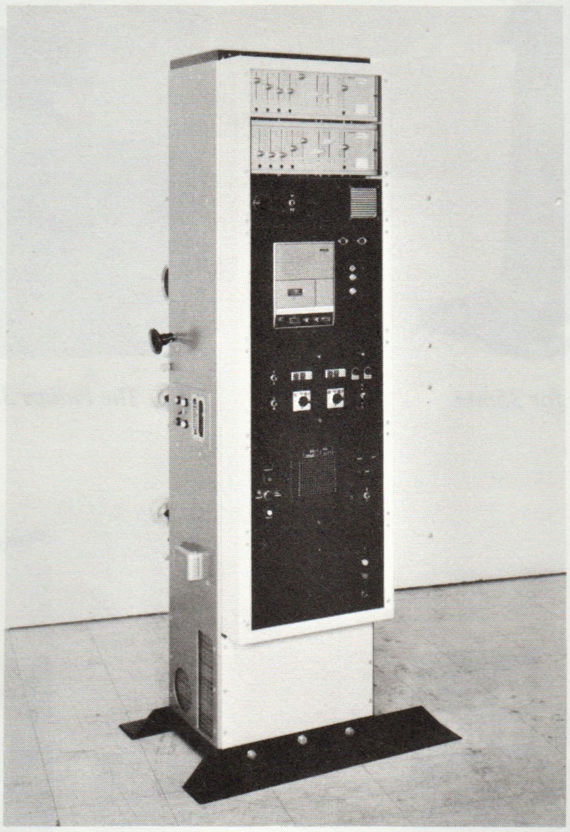


Fig.6. Back of FP30 Projector showing matrix programmer for automation, including cassette audiotape player and control deck for non-rewind attachment.

New Intermittent Mechanism

When the film is required to travel in the forward or reverse direction up to a fivefold speed in theatres, and also in post-synchronizing and preview equipment, the intermittent sprocket is apt to cause difficulties which may result in damage to the film.

The intermittent mechanism introduced as the "Kinoton Cross" corresponds in size and high performance to the intermittent mechanism used in the FP 30; it can actually be substituted for it. The great feature of the "Kinoton Cross" consists in the possibility of declutching the intermittent drive system of the pull-down sprocket, and of simultaneously putting into operation a continuous drive system of this sprocket instead.

Changing over from intermittent travel to continuous travel is performed by a servo-motor after the intermittent mechanism on its flywheel has been slowed down and brought to a standstill by means of an electromagnet.

This "Kinoton Cross" not only allows forward and reverse travel of the film at a speed of up to 120 frames per second, but since the change-over to continuous travel takes place while the shutter is in the open position, it also offers the possibilities of single-frame projection and motorised frame-by-frame inching.

The 35 mm Projector FP 30 RR

This projector can be supplied with all the additional accessories as the FP 30 projector. Moreover, it is equipped with the "Kinoton Cross" described above.

By means of the matrix programmer and some additional circuitry, projection and rewinding can be performed fully automatically if two projectors with their film spools are used.

The FP 30 RR projector can moreover be supplied with horizontal film discs mounted on to it. In this way a projector for 20,000 ft of film is obtained which operates fully automatically, rewinding the film at a fivefold continuous speed by means of the "Kinoton Cross".

A 35 mm Projector for Use in Studios

The ST version of the FP 30 projector has been specially developed for use in studios. The film transport mechanism at the front is suitable for reels of 2000 ft of film. Its "Kinoton Cross" mechanism offers the possibility of projecting the film in the forward or reverse direction a speed of 24 or 25 pictures per second, of projecting the pictures one by one, and of bringing the projector to a standstill so that one frame is displayed. In addition, when the sprocket driven by the "Kinoton Cross" is made to rotate continuously, the film can travel in either direction at a speed of up to 120 frames per second.

At the side opposite to that on which the projection device is mounted, a 17.5 and 35 mm perfotape reproducer is provided for reels of up to 600 m of film. (Fig. 7)

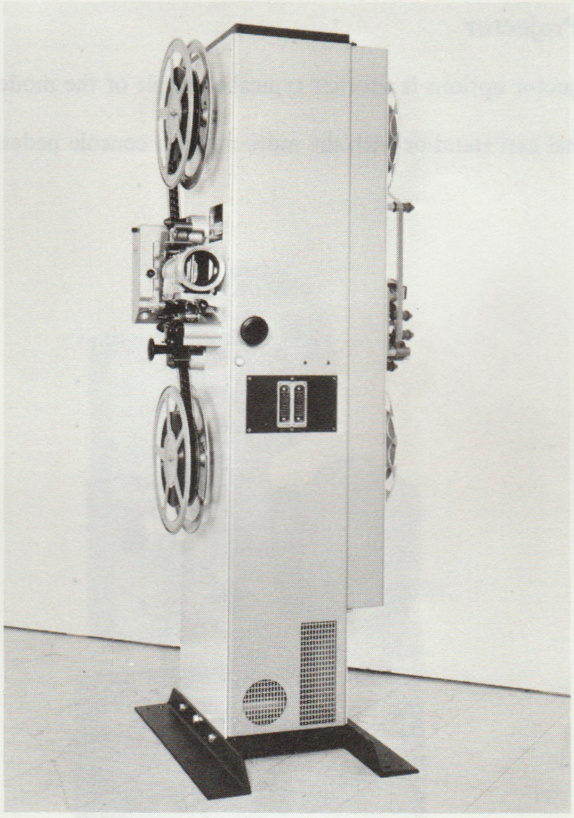


Fig. 7. FP30 Projector Model ST for studio use, showing 17.5mm Perfortape reproducer mounted on the rear face.

The projector and the sound part are electrically coupled in such a way that by acting on a press button either the projector part or the sound part or both of them can be driven synchronously by a single motor. Additional sound equipment can conveniently be linked to it.

An inherent feature of this projector is its property of automatically changing over to single-frame projection when it is switched off. This permits the film to travel in the forward or reverse direction with an accuracy of a single frame. The desired frame can be chosen either by hand-operated frame-by-frame inching, by means of a double sensor acting on cue marks or by a built-in preset electronic frame counter.

The projector can be equipped with an automatic lamp turret for 400 W halogen lamps or for 500 W or 700 – 1600 W xenon lamps and a pivoted filter for correcting the colour temperature in case of need.

All functions, including focusing and framing, are remote-controlled so that they can be operated either in the projection room or in the studio. The projector can be provided with an amplifier equipment for sound reproduction or for sound recording and reproduction.

The spoolboxes are square and made of plexiglass. On request a plexiglass noise-suppressing door can be supplied for closing the film path of the projector.

Xenon Lamp House 2500/4000 W

This lamp house has been designed for horizontally operating xenon lamps ranging from 2500 to 4000 W. With rotating shutter and an f/1.6 lens the luminous flux will be about 13,000 lumens with a 2500 W lamp and about 15,000 lumens with a 4000 W lamp.

Use is made of a heat-transmitting dichroic-coated mirror with a diameter of 30 cm. Cooling is achieved by means of a ventilator with a capacity of 10 cubic metres per minute (350 cfm). The safety circuit is operated by sensors which react on the temperature of the air flow. The automatic ignition device is not in the housing but mounted underneath the upper cover.

The Westrex 7000 35 mm Projector

The Westrex 7000 Series of Projector options is another typical example of the modern versatile projector. (Fig. 8)

It can be used with the traditional cast stand or with the more modern console pedestal unit containing amplifiers and other equipment.

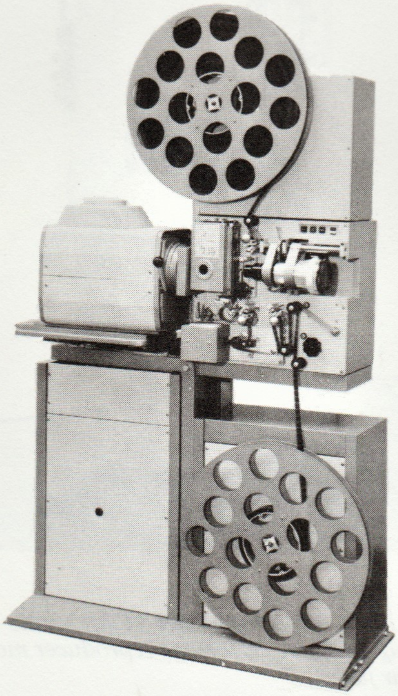


Fig.8. The Westrex 7000 35mm Projector.

It is normally equipped with 6000 ft spools so that two projectors are needed for continuous presentation. It can of course, be used also as a single projector in automated situations by providing a long-playing device such as the Westrex 5035 or the Cinemeccanica D.B.G.2 x 4, or the Philips S.T.200 Non-Rewind device.

The optical system uses a single focusing lens supplemented by two lenses for Cinemascope and normal wide screen. Swinging the supplementary lens into place changes the aperture plate automatically. The long curved gate has parallel opening for easy access.

The take-up shaft has a sophisticated torque motor drive; the shutter is of the drum type and the intermittent unit and curved gate is an integrated assembly.

The drive uses steel reinforced polyurethane toothed belts and the lubrication with pump for the intermittent is very simple with few oiling points.

The Ernemann 12 Projector

The Ernemann 12 projector is of interest as being a long-run capacity machine which is available both as 35 mm and as dual-gauge for both 35 mm and 16 mm, the change of format being quick and simple. Although compact, standing on a floor space 1.5 x 0.6 m, it takes 2700 m capacity 35 mm spools, both feed and take-up positions being mounted below the projector head. For 16 mm operation, the normal spool size is 1500 m, similarly mounted.

The console pedestal stand can contain built-in rectifier and 60 w amplifier, as well as automatic controls and a magnetic sound system if required. The pre-amplifier and exciter lamp rectifier are also built-in. (Fig. 9)

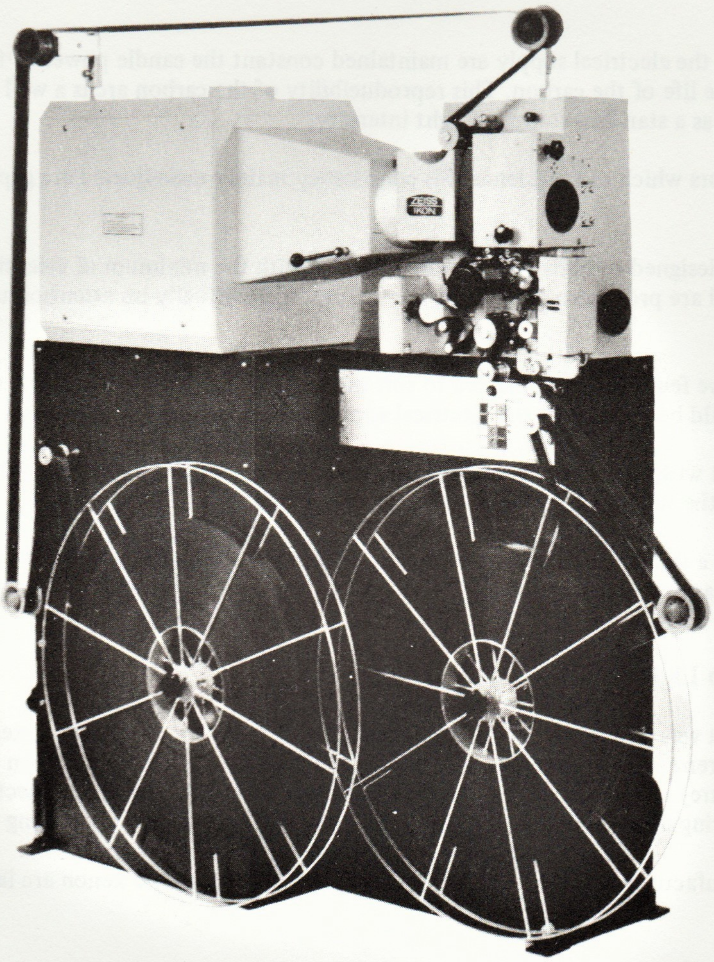


Fig.9. The Erneman 12 Dual-gauge 35/16mm Projector.

The regular lamphouse is the Xenosol 1600, taking a horizontal Xenon bulb of either 700 W, 1000 W or 1600 W. The lamp supply voltage is 65-75 V and the operating voltage for the 1600 W lamp is 72 V at the rated current of 65 amps. With a projection lens aperture of f/1.6 this lamp produces an output of 6700 lumens. A two-lens turret mount for rapid change-over between normal and anamorphic projection can be supplied.

14. LIGHT SOURCES AND LAMP HOUSES: GENERAL PRINCIPLES

The light is the life force of Picture Presentation

The light which is projected into the auditorium is one of the vital factors in cinema presentations.

Its intensity, colour and stability establish picture quality and unless these factors are properly obtained and maintained the whole artistry embodied in the film being projected can be lost as far as the patron is concerned.

Although for many years the carbon arc was firmly established as the source of light for the 35 mm cinema projection the Xenon Arc has now become the standard source.

Today, with the development of large wide screen techniques it is more than ever essential that every part of the projection equipment is kept in the peak of condition.

The paths which the light rays have to travel are rather tortuous before the radiant energy which leaves the crater of the arc finally reaches the retina of the patron's eye. If we study this path of light it gives us some guidance as to maintaining the standard of performance required today.

The Carbon Arc Light Source

Most carbon arcs in use today are supplied with Direct Current, the crater produced on the end of the positive carbon being used as the source of light. From this crater, radiation is emitted of great intensity and with a colour similar to sun light.

Provided the arc gap and the electrical supply are maintained constant the candle power of the light source will remain consistent throughout the life of the carbon. This reproducibility of the carbon arc is a well known property and at one time was considered as a standard source of light intensity.

There are, however, factors which can influence this consistency mainly maladjusted arc gaps and the electrical supply to the arc.

The modern arc lamp is designed to burn the carbons correctly with the minimum of attention. If automatic feeds are functioning correctly and are properly adjusted the arc will run with virtually no attention until the carbons have to be replaced.

Once positive and negative feed rates are adjusted to suit the burning conditions of the arc, negligible adjustment of the manual controls should be required if the electrical supply to the arc remains constant.

If continuous adjustment with the controls are necessary then attention should be paid to the alignment of the carbon holders and feed guides, the slipping clutches and the electric motor feeds.

All rectifiers should have a fine control around the normal working conditions of the arc to enable corrections to be applied to the mains voltage variations.

The Xenon Arc Lamp Light Source

More than 40 years ago it was discovered that noble gases, helium, neon, argon, krypton, xenon and radon; when heated by an electric current emit intensive radiation. Since that time it has become known that of all these noble gases, xenon (the most rare) provides the most efficient light source with a continuous spectral energy distribution, the highest colour rendering index and with a spectral composition most closely resembling that of daylight.

About 25 years ago manufacturers in West Germany were able to mass produce xenon arc lamps for projection light sources.

Xenon lamps offer many advantages, including:

- Uniform output of almost constant spectral distribution
- Economical long-run operation – a life of 1000 to 2500 hours
- Minimum maintenance
- Arc stability unaffected by exhaust air conditions
- Absence of smoke and ashes
- Availability in a range of sizes up to 6500 watts

Their spectral energy distribution is almost unaffected by the load and changes only slightly during the life of the lamp, gradually becoming less blue.

All the bulbs now made by both British and German manufacturers are known as **Ozone Free**, and the measured ozone concentration at the **lamphouse exhaust** for a 4,000 watt bulb is 0.01 ppm and 0.005 ppm for a 1600 watt bulb against a recommended maximum concentration of 0.1 ppm ozone in the **working area.**

All rectifiers used in conjunction with Xenon arc lamps must be specifically designed as they have to provide functions including:

- Rectification
- Filtering
- Ballasting/regulation
- Light stability
- Sufficient open current voltage
- Fast starting current rise time
- Peak inrush current limiting
- Control of starting transient duration
- Critical damping of transient
- Compensation for lamp tolerances
- Output adjustability without affecting the other parameters.

The Mirror

The light from the arc crater is focussed to the film aperture in most arc lamps by an elliptical mirror which can be tilted in two planes. Once set in correct alignment this should rarely need adjustment, except after cleaning or mirror replacement.

There are three main types of mirror:

- Glass with a metallized surface of silver or aluminium
- Polished and protected metal
- Glass based dichroic. (Cold mirror)

Due to arc 'splutter' in the carbon arc it is generally necessary to use either the metal or metal coated glass mirror except in the largest sizes.

With the Xenon arc however a cold or Dichroic mirror may be used which, by reflecting the wanted visible light ray but allowing the infra-red heat rays to pass through the mirror reduces the heat in the film gate The reduction in heat is approximately 40% thus preventing deterioration of the lenses and reducing film flutter thereby giving better ability to adjust and hold focus correctly.

The Flicker Shutter

At this point approximately 50% of the available light is lost. This is a function of shutter design and there is no control over this.

The Film Aperture

Here again light losses occur due to covering a rectangular aperture with a circular spot of light. The introduction of wide screen apertures with cropped gates have made these losses greater.

The Projection Lens

Further losses are inevitable at the lens and anamorphic attachments. These are functions of lens design, quality of the optical glass, skill of manufacture and the choice of the multi-coatings for the greatest transmission of light and colour. The surfaces of the lenses must be regularly cleaned following the manufacturers recommendations.

The Porthole Glass

Loss in the order of 12% usually occurs at the porthole glass. This can be made worse if they are allowed to become dirty due to dust deposits.

Atmospheric Absorption

Fog and tobacco smoke in the auditorium seriously influence the brightness of the picture. Good air conditioning and the separation of patrons who wish to smoke into specific areas with extra air extraction, improve the situation. Full advantage of arc flexibility should be taken and the arc run at a higher current level to off set losses when they occur.

Screen Reflectivity

At the screen the light produced by the projector is converted to a sensation of brightness to the patron.

However powerful the projector, the screen surface has the final influence as to what the customer sees.

The general use of metallised screen surfaces has given additional problems to the projection engineer and because of the variation in reflectivity with angle of view it has become necessary to curve the screen to give a better uniformity of brightness from side to centre.

What we are aiming to do?

Light loss under one of the above headings is bad enough but when two or more light losses are added together the total loss can do great harm to the picture presentation.

From the foregoing considerations of the light path it is clear that in a number of instances it is possible to exercise some control over the ultimate screen brightness and constant checking and scrupulous cleanliness of all glass surfaces will help in this direction.

Recommendations for screen luminance are given in the British Standards Institution publications:

BS 5550: 7.2.2:1978 for 16 mm projection

BS 5550: 7.2.3:1978 for 35 mm projection

BS 5550: 7.2.4:1978 for 70 mm projection

The American standard luminance for the centre of the screen with the projector running but with no film in the 35 mm gate calls for 55^{+14}_{-21} candelas per square metre (equivalent to approximately 16 foot-lamberts in English units) when measured from a representative position in the centre (of the width) of the auditorium and two thirds of the distance back from the screen to the rear row of seats.

The edges of the screen should have between 65 and 85% of the centre luminance.

International Standards Organisation are generally similar in nature although a somewhat lower norm of 40 cd/m^2 with a more limited lower tolerance of $^{+25}_{-10}$ have been adopted.

The same values for projecting 70 mm prints have been proposed except in Great Britain where the higher screen luminance possible from the larger projector aperture is recognised by the specifications of a standard 80^{+20}_{-19} cd/m^2.

It should be noted that the incident brightness falling on a screen is measured in lux which is lumens per square metre and in English units lumens per square foot or foot-candles (1 lumen per square foot = 10.76 lux).

The reflected light or luminance however is measured in candela per square meter and in English units foot lamberts (1 foot lambert = 3.426 cd/m^2).

The reflectivity is a function of the ratio of the two measurements and for a matt white screen is approximately 80%, depending on the quality of the screen, its age and the frequency with which it is cleaned. Here again tobacco smoke is a main cause of lowering the efficiency of the screen.

A photometer should be used regularly by the projectionist in order to monitor the overall performance and to enable him to plan the maintenance to obtain consistent results.

15. LIGHT SOURCES AND LAMP HOUSES

CARBON ARCS: THEORY

The source of light in an arc lamp is the flame between two electrodes, usually of carbon which are copper covered and produced to specific formulations so that they serve the particular purpose intended.

The arc cannot start spontaneously. After a difference of potential has been established, the two electrodes must be brought together so that a current can flow around the circuit.

The circuit is then broken by slowly separating the electrodes. When the circuit is broken, a spark jumps the gap between the two electrodes, due to parts of the conductor being broken away and heated to incandescence.

If the pressure between the electrodes is sufficiently high, and the distance between the electrodes is not too great a continuous discharge will take place across the gap, the electrodes will become incandescent and the material of which they are comprised will gradually be consumed and vaporized. The stream of incandescent vapour between the electrodes gives rise to an intensely luminous light.

The carbon arc used in cinematograph film projection is operated from a Direct Current supply and the source of light is a ball of luminous gases formed in the crater of the positive carbon from the combination of various mineral salts which form the core of the carbon.

The light is collected by means of a concave mirror so therefore it is not possible to supply the electrodes with current at a point close to the arc as this would obstruct the beam so the current must travel along the length of the carbon and to reduce their resistance the rods are usually copper coated.

The actual voltage required to maintain the arc is comparatively small varying between 30 and 60 volts for a range of arc current of 30 to 90 amperes for the 35 mm film projection.

For wide screen presentation, a pressure of approximately 80 volts would be required with an arc current of 160 amperes.

For arc lamps any current variation causes area alleviation of the positive crater resulting in unstable illuminations; to remedy this a steadying resistance is connected in series with the arc supply, thus varying the potential across the arc terminals inversely as the current. A minimum of an additional 20 per cent of the voltage required on the arc terminals is necessary for steadying the arc.

A ballast resistor or other form of controller is necessary and usually adjustable. For an arc requiring a pressure of 40 volts across its terminals while operating at 60 amperes, the effective resistance across the arc will be $\frac{40}{60}$ or 0.66 ohms.

If the line voltage supplying the arc is 70 volts, then to maintain stability the ballast resistor must be set at $\frac{70 - 40}{60}$ or 0.5 ohms.

The arc resistance not only depends on the current flowing through it but also on the arc gap between the positive and negative electrodes and to some extent on the magnetic control of the arc lamps.

The wider the arc gap the higher the arc voltage at the same current. Little or no magnetic control on the flame tends to produce more overlapping of the flame round the top of the positive carbon giving a lower arc voltage and corresponding lower resistance. Conversely, the less the flame overlaps the higher the arc voltage and the arc resistance becomes.

These magnetic control effects are however rather small in comparison with the changes produced by variations in the arc gap which can influence the arc potential by several volts.

The arc establishes its own resistance at a given current so that providing the electrical supply voltage and its associated ballasting is sufficient to maintain the arc, the arc voltage will be the same in a particular lamp at the same current and arc gap irrespective of the line voltage.

Obviously for a low line voltage, the variations of arc resistance by changing the arc gap will produce a more violent change in the electrical conditions at the arc since the percentage change of total resistance in the circuit would be more with the lower ballast resistance than for a high line voltage with a correspondingly higher ballast.

This means that for equivalent low line voltages the striking current would be high and the arc is likely to become extinguished quicker if the arc gap is too wide. However with a suitably responsive automatic feed mechanism on the arc lamp a satisfactory performance of the arc can be maintained with an improvement in electrical running costs as less energy is dissipated in the ballast. The variations of the Ammeter and arc voltmeter pointers during the burning of the arc under these low line voltage conditions are more noticeable, although no serious effect on the light is evident.

For high line voltages with more ballasting in the circuit the arc current does not vary so violently with small arc gap changes, but there is a greater electrical loss in the ballast. The striking current is lower and the arc may be run at a wider gap without becoming extinguished.

It has been observed that there is a tendency for an underloaded arc to 'surge', i.e. the Beck effect at the crater is periodically lost, is more likely to occur with a high line voltage system than a low one.

Beck of Germany invented the effect carbon in 1910 thus creating the high intensity carbon which, compared with the low intensity carbon, has a larger specific load and a higher luminous density and colour temperature.

In general, carbons are burned at arc gaps varying from 4 mm to 8 mm depending on the individual operating conditions and performance figures for carbons are given for arc gaps of the order of 6 to 7 mm. These are the more general methods of burning and most arc lamps have their arc gap indications marked to these conditions.

Fig. 1 illustrates the change in screen light and positive burning rates for an 8 mm positive and 7 mm negative combination burning at a constant amperage at varying arc gaps. The change in light output from the smallest to the largest gap is approximately 12%, a corresponding increase in positive burning rate also being found as the gap increases. The wattage of the arc increases.

As the gap is increased the longer arc flame becomes more influenced by draughts in the lamphouse, while at the short gap the obscuration of the crater by the negative carbon point becomes more apparent and also carbide deposits on the negative tip become more noticeable.

Fig. 2 illustrates the variation in the positive burning rate and screen light from the same combination of carbons when the ballast resistance and supply voltage remain constant. These conditions are such that as the arc gap is shortened the current rises and the arc voltage is reduced and vice versa. The arc wattage remains constant.

Starting from the 7 mm gap as it is closed to 5 mm the light increases by 6% and the positive burning rate is increased by the same amount.

As the gap is increased from 7 mm to 9 mm the screen light falls by 8% with a corresponding reduction in positive burning rate and a greater susceptibility of the arc flame to draughts.

The correct carbons must be used for the design of the lamphouse and should not be operated at the extreme limits of the recommended current ranges.

It is advisable to burn them nearer to the middle of the range. This will take care of voltage variations to which the incoming supply is prone. It also gives that reserve for additional light which is extremely useful when there are smoke-laden or foggy atmospheres or, should the current become reduced due to incoming supply variations, the carbons would still be comfortably within their safe current rating.

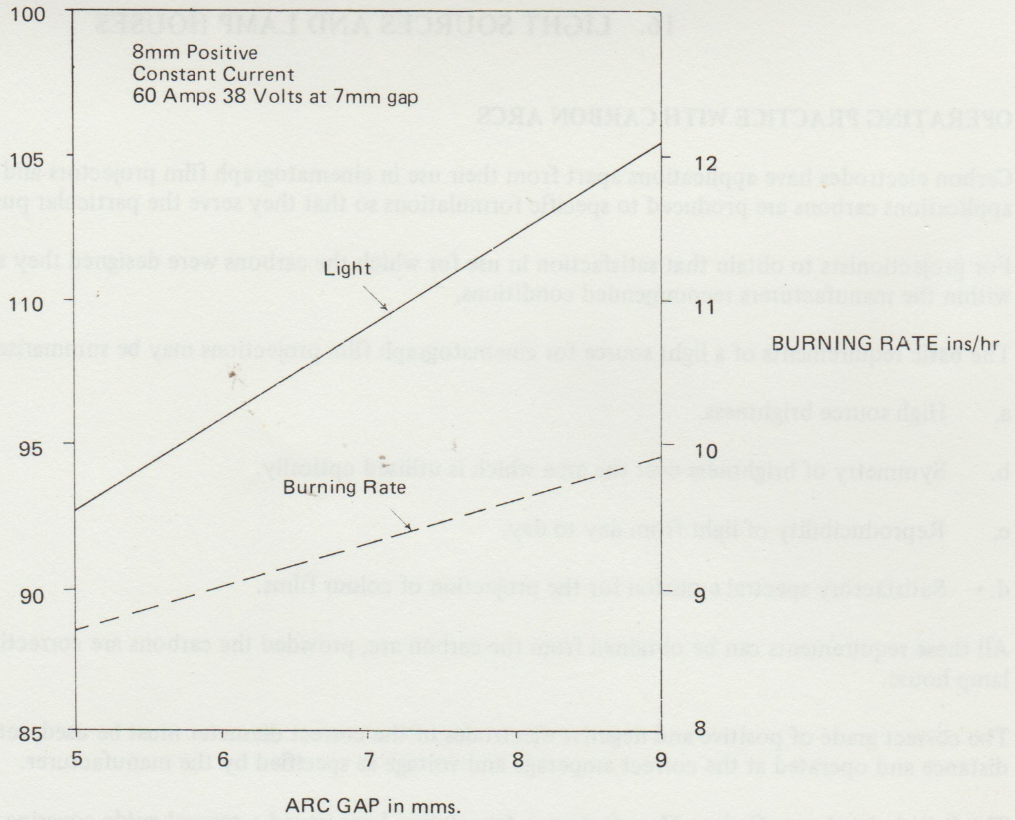

8mm Positive
Constant Current
60 Amps 38 Volts at 7mm gap
Light
Burning Rate
BURNING RATE ins/hr
ARC GAP in mms.
100
105
110
95
90
85
12
11
10
9
8
5
6
7
8
9

Fig.1

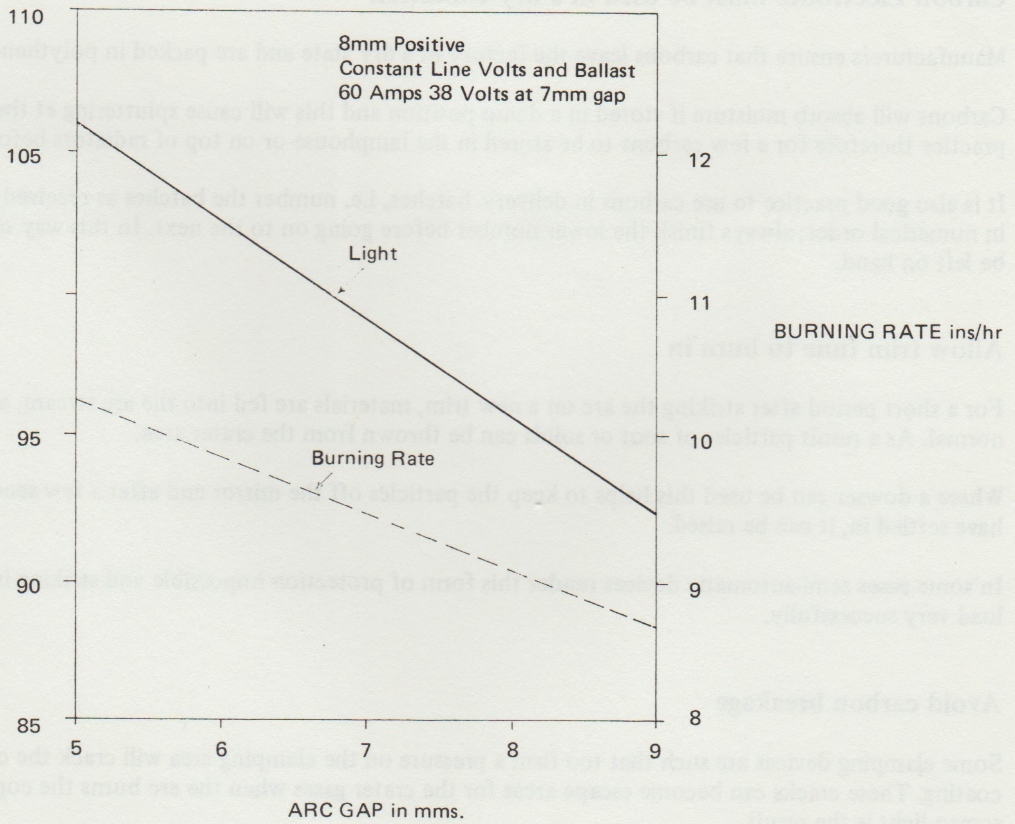

8mm Positive
Constant Line Volts and Ballast
60 Amps 38 Volts at 7mm gap
Light
Burning Rate
BURNING RATE ins/hr
ARC GAP in mms.
110
105
95
90
85
12
11
10
9
8
5
6
7
8
9

Fig.2

OPERATING PRACTICE WITH CARBON ARCS

Carbon electrodes have applications apart from their use in cinematograph film projectors and for each of the applications carbons are produced to specific formulations so that they serve the particular purpose intended.

For projectionists to obtain that satisfaction in use for which the carbons were designed they should be operated within the manufacturers recommended conditions.

The basic requirements of a light source for cinematograph film projections may be summarised as follows:–

a. High source brightness.

b. Symmetry of brightness over the area which is utilised optically.

c. Reproducibility of light from day to day.

d. Satisfactory spectral emission for the projection of colour films.

All these requirements can be obtained from the carbon arc, provided the carbons are correctly operated within the lamp house.

The correct grade of positive and negative electrodes of the correct diameter must be used, set at the correct gap distance and operated at the correct amperage and voltage as specified by the manufacturer.

The British Arc Lamp Carbon Manufacturers Association have issued a general guide covering these points which is included at the end of this section and can be used as a comparison for the specific instructions supplied for the use of the equipment at any particular installation.

Carbon Electrodes must be used in a dry condition

Manufacturers ensure that carbons leave the factory in a dry state and are packed in polythene bags to keep them so.

Carbons will absorb moisture if stored in a damp position and this will cause spluttering at the arc. It is a good practice therefore for a few carbons to be stored in the lamphouse or on top of radiators before they are used.

It is also good practice to use carbons in delivery batches, i.e. number the batches as received in on-going order and use in numerical order; **always** finish the lower number before going on to the next. In this way old deliveries will never be left on hand.

Allow trim time to burn in

For a short period after striking the arc on a new trim, materials are fed into the arc stream, at a rate faster than normal. As a result particles of soot or solids can be thrown from the crater area.

Where a dowser can be used this helps to keep the particles off the mirror and after a few seconds when the carbons have settled in, it can be raised.

In some cases semi-automatic devices render this form of protection impossible and striking is also carried out on full load very successfully.

Avoid carbon breakage

Some clamping devices are such that too firm a pressure on the clamping area will crack the carbon under the copper coating. These cracks can become escape areas for the crater gases when the arc burns the copper away and uneven screen light is the result.

Dropping a copper-covered carbon on a hard surface area may cause a breakage in the carbon which will not be discovered until the protective copper is burned away in the arc.

Carbons are robust enough to stand up to normal handling and it is only abnormal treatment which results in carbon breakages, **so handle the carbons with care.**

Extract and Ventilation Air

The volume of the lamphouse extract air is determined by the size of the arc and the flow must be interlocked with the arc supply to prevent the arc from operating without extract air.

In order to maintain a steady arc without flicker it is necessary to maintain very steady air conditions within the lamphouse enclosure.

This condition can, in some cases, be difficult to obtain due to the wind causing static pressure changes depending upon the position and form of the outside walls of the building.

Should this occur it can be solved by positioning the top (delivery end) of the extract duct in an area least affected by eddy currents and fitting the outlet with a wind-operated directional cowl, preceded by an extract fan with a high water gauge capacity.

A throttle should also be fitted at the lower end of the ducting system above the lamphouse extract fans. This throttle is adjusted to pass marginally more air than the lamphouse delivers. Changes in outside air pressure are then not transmitted to the lamp houses and they are enabled to run at a steady condition.

PROJECTOR LIGHT OUTPUTS

The figures quoted in the following tables have necessarily been obtained under controlled laboratory conditions and without taking into account the light loss of the film-mechanism shutter. They are therefore given as an indication of what can be expected by way of light output from arc-lamps of the orthodox straight-arc and rotating-positive types under virtually ideal conditions.

In practical theatre operation there are many factors which will lower these ideal figures and in any case you have to make an immediate reduction to one-half to allow for the rotating film-mechanism shutter which is always operating when light readings are taken in cinemas.

The lens used on the test figures was a surface-coated type with an "f" value of 1.9 and the type and speed of your own lens may seriously reduce the figures applicable to your cinema. So may the condition of lenses, porthole glasses and a host of other items.

The quoted figures, therefore, must be considered only as a guide; note the changes in the 9 mm Link CA data compared with the former figures.

Carbons		Burning Conditions		Approximate Burning Rate In. Per Hour		Screen Lumens
Positive	Negative	Amps	Arc Volts	Pos.	Neg.	f/1.9 Bloomed
COPPER COVERED						
6 mm LINK CA	5 mm LINK NC	30	31	6.	4.125	8,150
		35	34	9.	4.375	8,650
		40	37	13.25	4.5	10,400
6 mm LINK CC	5 mm LINK NC	35	32	8.	4.375	7,120
		40	35	11.5	4.5	9,800
		45	38	15.25	4.625	11,100
7 mm LINK CA	6 mm LINK NC	40	34/5	7.75	3.25	9,200
		45	37	10.75	3.5	11,750
		50	39/40	15.25	3.75	13,950
7 mm LINK CC	6 mm LINK NC	45	33/4	8.	3.5	10,600
		50	36/7	10.75	3.75	12,750
		55	38/9	14.75	4.	15,080
8 mm LINK CA	7 mm LINK NC	50	39/40	7.5	2.875	12,250
		55	41/2	10.	3.	14,450
		60	44	12.5	3.25	16,750
		65	46	16.5	3.5	18,400

Carbons		Burning Conditions		Approximate Burning Rate In. Per Hour		Screen Lumens
Positive	Negative	Amps	Arc Volts	Pos.	Neg.	f/1.9 Bloomed
8 mm LINK CC	7 mm LINK NC	55	40	8.5	3.	13,100
		60	41	10.5	3.25	15,100
		65	43	13.25	3.5	16,800
		70	45	16.25	3.75	18,600
8 mm LINK CD	7 mm LINK NC	70	44/5	11.	3.25	18,400
		75	46/7	13.25	3.625	21,100
		80	48/9	18	4.	23,000
9 mm LINK CA	7 mm LINK NC	55	36	6.0	2.75	14,000
		60	38	7.6	3.0	16,000
		65	40	9.2	3.25	18,000
		70	42	11.2	3.5	20,000
		75	44	13.8	3.75	22,000
9 mm LINK CC	8 mm LINK NC	70	45	10.	3.	15,900
		75	47	12.25	3.125	18,150
		80	50	14.75	3.25	20,100
UNCOPPERED ROTATING						
9 mm LINK BC	8 mm LINK NC	75	49	11.25	2.75	16,000
		80	51	13	3.	18,500
		85	53	15.5	3.25	19,500
10 mm LINK BC	9 mm LINK NC	85	52	8.75	3.	18,000
		90	54	10.5	3.125	19,000
		95	56	13.5	3.25	21,000
		100	58	16.5	3.375	23,000
11 mm LINK BC	9 mm LINK NC	100	57	11.5	2.5	19,000
		105	59	12.75	2.625	20,500
		110	61	14.5	2.75	23,000
		115	62	18.	3.	26,000
9 mm LINK BD	8 mm LINK NC	80	52/3	9.5	3.	16,500
		85	54/5	11.75	3.125	19,000
		90	56	13.75	3.25	20,500
		95	57	16.5	3.375	22,000
13 mm LINK BD	9 mm LINK NC	100	56	11.	2.5	20,500
		105	58	14.25	2.625	21,000
		110	60	17.	2.75	24,000
		115	62	19.75	3.	26,000
11 mm LINK BD	9 mm LINK ND	115	54	11.	3.	22,000
		120	56	13.5	3.25	25,500
		125	58	15.75	3.25	27,000
		130	60	19.	3.5	29,000
13.6 mm LINK BD	11 mm LINK NC	130	62	6.5	2.125	19,000
		135	64	8.	2.25	20,500
		140	66	10.	2.375	22,000
		145	68	11.5	2.625	24,000
		150	70	13.	2.75	26,500
		160	72	16.	3.	29,000

'CARBON ELECTRODES AND OPERATING CONDITIONS'

To obtain the satisfaction in use for which the carbons were designed they should be operated within the manufacturer's recommended conditions, as shown below:

HIGH INTENSITY

D.C. Copper Covered Positive

		Diameter	Amperes	Arc Volts
Link CA:	A copper covered carbon having a core impregnated with rare earths, providing a high light output in limited electrical conditions.	6 mm	30–40	27/34
		7 mm	40–50	32/40
		8 mm	50–65	38/46
		9 mm	60–70	40/44
		10 mm	70–85	42/50
		11 mm	80–90	46/56
Link CC:	A positive designed for high current densities. Gives an exceptionally high light output with a low rate of burning. Normally operates at five amperes higher than Link CA grade.	6 mm	35–45	31/37
		7 mm	45–55	34/39
		8 mm	55–70	41/46
		9 mm	70–80	41/46
		10 mm	80–90	48/52
		11 mm	85–95	48/58
		12 mm	90–100	50/60
Link CD:	Is a grade of positive specially produced for use in the modern high powered mirror arcs.	8 mm	70–85	44/50
		9 mm	80–95	48/54
		10 mm	95–110	50/56

D.C. PLAIN ROTATING POSITIVE

		Diameter	Amperes	Arc Volts
Link BC:	A positive employed in lamps where the electrical contact is close to the crater of the carbon. Is the standard positive of this class.	9 mm	75–85	49/53
		10 mm	85–100	52/58
		11 mm	100–115	57/62
Link BD:	A rotating positive carbon having a shell and core designed to carry higher currents than Link BC grade.	9 mm	80–95	52/57
		10 mm	100–115	56/62
		11 mm	115–130	54/60
		13.6 mm	130–160	62/72

D.C. COPPER COVERED NEGATIVE

		Diameter	Amperes
Link NC:	A copper covered negative, the standard for use with most grades of D.C. high intensity positive carbons.	5 mm	30–45
		6 mm	40–55
		6.5 mm	50–60
		7 mm	55–70
		8 mm	75–95
		9 mm	100–115
		10 mm	125–135
		11 mm	130–150
Link ND:	A negative carbon made to withstand the high current loadings demanded by the arc lamps employed in Todd-AO, Cinerama, Drive-in and other forms of panoramic film presentation.	8 mm	95–110
		9 mm	115–130
		11 mm	130–160

HIGH INTENSITY A.C. CARBONS

		Diameter	Amperes	Arc Volts
Link AC:	The standard high intensity carbon for use on A.C. lamps. Copper covered and designed for stability, low burning rate, wide current range and high light output.	7 mm	55–70	21/24
		8 mm	70–90	23/27
		9 mm	90–100	24/27

LOW INTENSITY

		Diameter	Amperes	Arc Volts
Link LP:	Is a plain positive carbon having a smooth shell with a soft quirted core giving a good steady light at a very low rate of burning.			
Link LQ:	A negative carbon with a plain shell and a copper covered core.	10 mm Pos) 7 mm Neg)	10–20	48/52
		12 mm Pos) 8 mm Neg)	15–30	48/52
		14 mm Pos) 9 mm Neg)	25–40	48/52

STAGE AND SPOT LIGHTING

		Diameter	Amperes	Approx.
Link OWF:	A white flame carbon having a clean hard shell of high conductivity and a core impregnated with rare earths to give a white light of perfect colour balance and high emission efficiency on A.C. supply.	14 mm	30–40	40
		16 mm	30–50	40
		18 mm	50–60	40
		20 mm	60–70	40
		22 mm	70–80	45
		25 mm	80–85	45
Link SP:	A correct uncoppered positive carbon specially designed for use in D.C. Spotlights and Stage Arcs.	14 mm	25–35	48/52
		16 mm	35–45	48/52
		18 mm	45–55	48/52
		20 mm	55–65	48/52
		22 mm	65–75	48/52
		25 mm	75–85	48/52
Link SC:	A negative carbon, cored and copper covered to be used in combination with the Link SP positive at high current densities on D.C.	10 mm	45–65	
		11 mm	60–75	
		12 mm	70–85	
Link SQ:	A negative with a plain shell and a copper core, used with the SP positive for all normal D.C. stage lighting and spotlighting work.	9 mm	25–35	
		10 mm	35–45	
		11 mm	40–50	
		12 mm	45–55	
		14 mm	55–65	

17. LIGHT SOURCES AND LAMP HOUSES

CARE AND MAINTENANCE OF ARC LAMPS

There are many different makes and models of projection arc lamps and lamphouses in use but in effect they are all similar in basic principles and matters concerning their care and maintenance are, in general, common to them all.

Eliminating the optical system, which is covered in a separate section, the maintenance of the light source is covered under two sections – **mechanical** and **electrical**.

Mechanical

The carbon arc lamp burns up carbon electrodes and since carbon itself is a somewhat dirty substance even when partially covered with copper, it will clog the working parts of the arc lamp leaving a film of carbon ash and particles of copper every time the arc is burnt. It is essential that all the working parts should be kept free and clean by means of daily attention.

Lubrication should be carried out as directed by the manufacturer using their recommended oils or greases due to the high heat level within the lamphouse.

Most lamphouses are made with a double 'skin', so arranged that a current of air is continually circulated to cool the outer casing. Make certain that this ventilation system is kept clean and clear and that the extract fan and motor are properly maintained. Check also that excessive solids do not build up on the inside of the extract ducting.

Most arc lamps incorporate a magnetic flame control which may be a permanent magnet or a wound electro-magnet. The positioning of a magnet of this kind is critical if steady burning is to be achieved. Keep the pole pieces clean and check occasionally that nothing has worked loose to allow the magnet to become slightly out of position with detrimental effects on the arc steadiness.

Check the arc imaging device for tightness so that it always throws an image of the arc on to the ground glass screen or card with accuracy. Do not allow movement to give false information; make a regular check using the arc focussing movement, watching the screen for peak light and checking back to see if the arc image is on the guide lines.

Electrical

Check the electrical contacts between the carbon electrodes and the 'jaws' or 'contacts'. These must be kept clean and smooth so they are allowed to grip the carbons over a good and clean bearing surface. Follow the manufacturer's instructions to the letter.

Alignment of the current-carrying 'jaws' and contacts is also a matter to check and correct when necessary otherwise a local arc will be set up between the carbon or its copper coating and the jaw and this will cause a pitted jaw. Pitted jaws are useless since the deterioration becomes additive.

Some of the rotating and positive types of arc lamps have silver contacts. These should be cleaned with metal polish never a file or emery paper.

Because the carbon 'jaws' or 'contacts' must move along as the carbons burn away and are fed together by the feed motors they must not be strained or allowed to stick and feed unevenly. Also because they move, the electrical connections must be flexible. Check regularly for signs of burning or perishing in order that immediate replacement can be made preventing a breakdown during a show.

Check that all electrical contacts are bright and tight.

Check that all insulation bushes, washers and packing pieces are not cracked and free from carbon dust.

Check the earthing of the case of the lamp house.

18. LIGHT SOURCES AND LAMP HOUSES

XENON LAMPS: THEORY

Xenon lamps are available in flash and continuous, AC and DC, long and short arc, vertical and horizontal, standard and ozone free, 2 lead, 3 lead and self-starting, quartz and sapphire varieties.

All the varieties have their specific uses but for projector light sources the main use is the continuous DC short arc, vertical or horizontal, standard or ozone free, 2 or 3 lead varieties and these have, in general, the same starting and running electrical requirements.

However, they usually differ somewhat in construction. For example the special quartz of an ozone-free lamp filters out the 184.9 nm xenon line.

There are also differences in other parameters. Most horizontal lamps require external magnets to cause the arc to burn horizontally.

All xenon short arcs have two electrodes spaced a few millimeters apart and they are enclosed in a quartz envelope. Both the electrodes are made of tungsten but the cathode is usually smaller and contains thorium to enhance the initial electron flow.

The lamps are filled with xenon gas under several atmospheres of pressure and employ a foil or rod seal.

Based on this construction, lamp ignition and operation require that:–

i. The open circuit between the two electrodes be bridged – so for a self-starting lamp an igniter to the gas must usually be used.

ii. The cathode be heated sufficiently to produce electron flow – hence adequate open circuit voltage is needed.

iii. The operating voltage and current level be reached before too much heat is conducted away by the foil or rod – hence the current transient is very important.

iv. The thermal shock on the stem be immunized hence maximum in-rush current must be limited.

v. An enclosure and proper coating be provided hence the requirement for a lamphouse with more than just optics.

vi. Ignition is accomplished by impressing a high voltage across the electrode gap. This voltage needs to be between 5 and 60 KV depending upon the particular lamp. In low wattage xenon systems the igniter is frequently part of the power supply unit. In systems above 450 watts however it is preferable to keep the ignition equipment inside the lamphouse for two reasons: high voltage and high frequency.

There are two categories of igniter circuits: repetitive and single pulse. The most common repetitive starter uses a Tesla coil circuit (see fig 1) with the AC input usually 220V supplied from the main rediffusion unit and the R.F. output transformer operating at about 1–3 MHz.

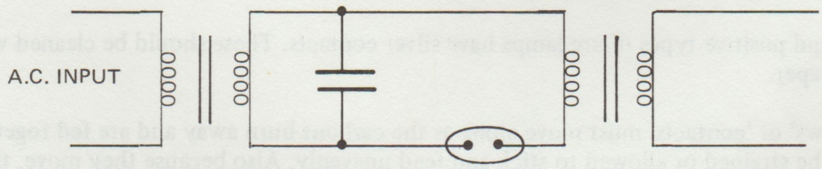


Fig.1

Single pulse igniters typically fire a silicon controlled rectifier ("SCR") to discharge a capacitor in the primary of the output transformer, as shown in fig. 2.

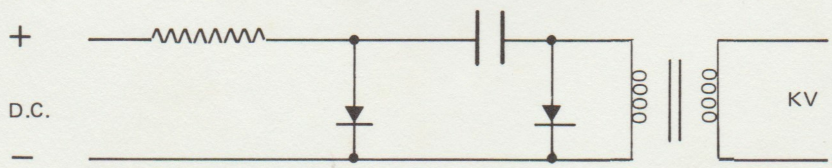


Fig.2

Since this circuit puts out only one pulse each time it is activated, starting the lamp is more difficult and may take longer.

Regardless of which type of igniter is used, there is still a problem: how to get this high voltage to the lamp without also impressing it across the output of the power supply.

One solution is to run the output adjacent to the lamp but not connected with it. This is used with xenon flash but not with the continuous type lamps.

The accepted method of applying high voltage to the lamp is with series coupling as shown in fig 3. With this circuit only the small voltage appearing across the R.F. capacitor is impressed on the output of the power supply.

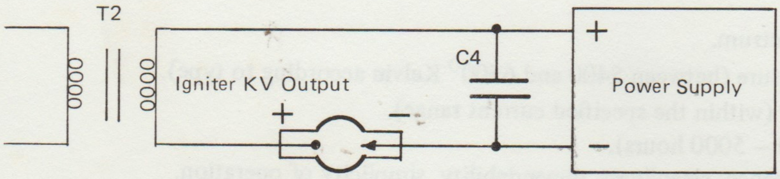


Fig.3

While this solves one problem it imposes a stiffer assignment on the R.F. transformer. With a 2.5 KW lamp, for instance, the transformer must now not only put out 50 KV during ignition but it must carry 100 amperes DC continuously.

One could solve the output transformer problem of high voltage with a relay that shorts out the transformer secondary after the lamp starts. However, this would call for relay contacts instead of the transformer secondary, to be designed for both high voltage and high current. Units with such relays have been built but have proven unreliable and costly.

The circuit in fig 2 with the connection in fig 3 is therefore today's most popular approach. Various configurations of the R.F. transformer are currently in use.

The igniter also requires a circuit to actuate it and this can be a simple push button as in fig 4.

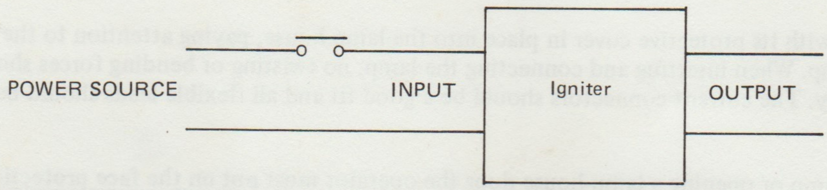


Fig.4

However in the case of the Tesla coil it usually includes a timing circuit and a polarity protector as in fig 5.

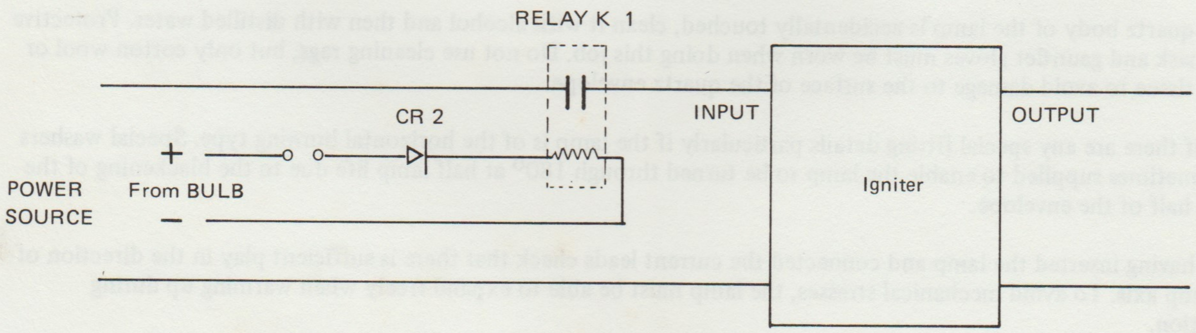


Fig.5

The RC timing circuit protects the lamp and the igniter from excessively long starting pulses. The polarity protector CR2 prevents the lamp from being started with reversed polarity, as this would instantly and permanently damage it.

Further refinements often include automatic in lieu of manual ignition, automatic cycling of the pulse train at given intervals if ignition fails to occur with the first pulse train and automatic stopping after several such cycles if the lamp repeatedly refuses to ignite.

19. LIGHT SOURCES AND LAMP HOUSES

OPERATING PRACTICE WITH XENON ARCS

Xenon arc lamps are manufactured and used for a wide variety of applications as a source of near-perfect artificial daylight as well as ultraviolet and infra-red.

There are several reasons for Xenon's increasing use:–

a. High intensity.
b. Point source.
c. Continuous spectrum.
d. Colour temperature (between 5400 and 6500^{O} Kelvin according to type).
e. Colour stability (within the specified current range).
f. Long life (1000 – 5000 hours).
g. Ease of maintenance, cleanliness, dependability, simplicity of operation.
h. Suitability for automation, adjustability of light intensity and variety of sizes (35 to 25000 watts).

The type used as light sources in theatre projection is the continuous DC short arc and can be of the 2 or 3 lead variety for vertical or horizontal operation and either standard or ozone free.

The two electrode and three electrode types are not interchangeable as the circuit and the ignition voltages are very different.

The manufacturers instructions must be followed with reference to the interchangeability of the vertical and horizontal operating types. Some are designed to be operated within 15 or 30^{O} of vertical, others may be operated within 20^{O} of the vertical and 20^{O} of the horizontal, others within 30^{O} of the vertical and 30^{O} of the horizontal and some within 100^{O} of the vertical.

The lamp house of course will be designed for either vertical or horizontal operation and a suitable lamp must be selected in accordance with the lamp house manufacturers recommendations.

When handling the lamp, the manufacturers' instructions must be followed with great care:

The lamp must be inserted with its protective cover in place into the lamp house, paying attention to the permissible burning positions of the lamp. When inserting and connecting the lamp, no twisting or bending forces should be transferred to the lamp body. The current connectors should be a good fit and all flexible leads should be slack.

NOTE Before handling a lamp or opening a lamp-house door the operator **must put on the face protection and gauntlet gloves.** The protecting sleeve must not be removed from the lamp until it is mounted and connected. Note the pressure of the lamp when cold is about 8 atmospheres and in working conditions of the lamp it is approximately 30 atmospheres.

Do not look into the light source and beware of lateral infra-red radiation (heat) when the lamp is operating.

If the quartz body of the lamp is accidentally touched, clean it with alcohol and then with distilled water. Protective face mask and gauntlet gloves must be worn when doing this job. Do not use cleaning rags, but only cotton wool or paper tissue to avoid damage to the surface of the quartz envelope.

Note if there are any special fitting details particularly if the lamp is of the horizontal burning type. Special washers are sometimes supplied to enable the lamp to be turned through 180^{O} at half lamp life due to the blackening of the upper half of the envelope.

After having inserted the lamp and connected the current leads check that there is sufficient play in the direction of the lamp axis. To avoid mechanical stresses, the lamp must be able to expand freely when warming up during operation.

Before initial operation, polarity of the electric connection should be checked so as to avoid reversed polarity.

The lamp housing **must be closed** during ignition and operation of the lamp. When an auxilliary mirror is used, it should be focussed correctly against the luminous arc. (Observe the instructions for the operation of the equipment.)

The current of the lamp may be varied within a certain range (see manufacturers table) without causing a change in the spectrum of the radiation. The maximum current values as stated in the table should never be exceeded.

When operating lamps with forced cooling, care should be taken that the velocity of the cooling air stream is high enough. Therefore in many cases, an exhauster fan will be necessary in addition to the blower installed in the lamphouse. The lamp base temperature should never exceed 230°C. **NOTE** The cooling air volume required for a 1600 watt lamp is at least $5m^3$/min (175 cfm) and for 2500 watt lamp $8m^3$/min (300 cfm).

When operating the lamp in a horizontal position, the deflection of the luminous arc caused by the convective gas stream within the envelope should be compensated for by an appropriately dimensioned magnetic field.

For reasons of safety, it is recommended to replace the lamps at the latest after the average life stated by the manufacturer has been exceeded by 25%.

When switching off the lamp, open the main switch but do not open the lamp house **until at least 10 minutes later**. When forced cooling is used the blower should be kept running for at least 5 minutes after switching off the lamp.

When removing a lamp, fit the protective cover around the cooled off lamp and follow the same precautions as when fitting the lamp.

Burnt out lamps may either be returned to the lamp manufacturer in their protective cover and original package or be destroyed as follows:–

Wrap the lamp without its protective cover in a large thick cloth, put it on a hard underlay and smash it with a hammer. **The safety precautions must be observed**.

Mechanically destroyed lamps should be packed separately, i.e. not in the protective cover.

20. LIGHT SOURCES AND LAMP HOUSES

CARE AND MAINTENANCE OF THE XENON LAMP

When working on the equipment while the lamp house is open, fit the protective cover around the lamp and wear the protective face mask and gauntlets. (See safety notes in previous section.)

Check the contact surfaces of the lamp and the connecting parts for cleanliness at regular intervals. If need be, clean them.

Contact resistances may lead to scorching of the bases and consequently to a premature failure of the lamp.

If an auxilliary mirror is used, it should be carefully refocussed after the maintenance work is finished.

Dust accumulating on the envelope after several hours of operation should be removed with a soft hair brush.

Replace the lamp towards the end of its life which may be indicated by:

a. Decrease of light output and lower colour temperature.

b. Unsteady picture – flicker.

c. Excessive current consumption: requires immediate replacement.

In any event, replace the lamp at the end of the life stated by the manufacturer.

NOTE The bulb becomes steadily more brittle as its life proceeds, hence a greater risk of explosion.

Should the envelope of the lamp be accidentally touched by the finger, the surface must be immediately cleaned using alcohol and soft clean cotton cloth, but avoid finger prints on the lamp envelope at all times.

21. LIGHT SOURCES AND LAMP HOUSES

PROJECTOR LIGHT OUTPUT

The whole question of the amount of light on the screen and its reflection and distribution is very complex and involves many factors.

Any particular combination of light source, projector lens and screen will produce a given amount of light to spread over the area of the screen but ventilation and other factors such as viewing distance and angle as well as screen area also affect the figure as far as the eventual screen brightness is concerned.

There are Standards on Screen Brightness but even these have to allow a wide variation between acceptable minimum and maximum.

Too bright a motion picture screen can cause more strain and deteriorate the picture image quality to a greater extent than one that is too dull and lacks 'sparkle'. In such cases, the 'highlights' become glare spots, contrast is destroyed and the appearance of 'flicker' most objectionable.

On the question of even light distribution over the screen surface, it is impossible in practice to obtain 100% uniform illumination over the whole area because of the limitations of the optical system. In comparing the sides and corners with the centre of the screen, a drop to 70% of the centre illumination is considered satisfactory and is recommended in British Standard 5550:7.2.1. This recommended ratio of illumination in fact creates the impression of slightly brighter edges to the picture.

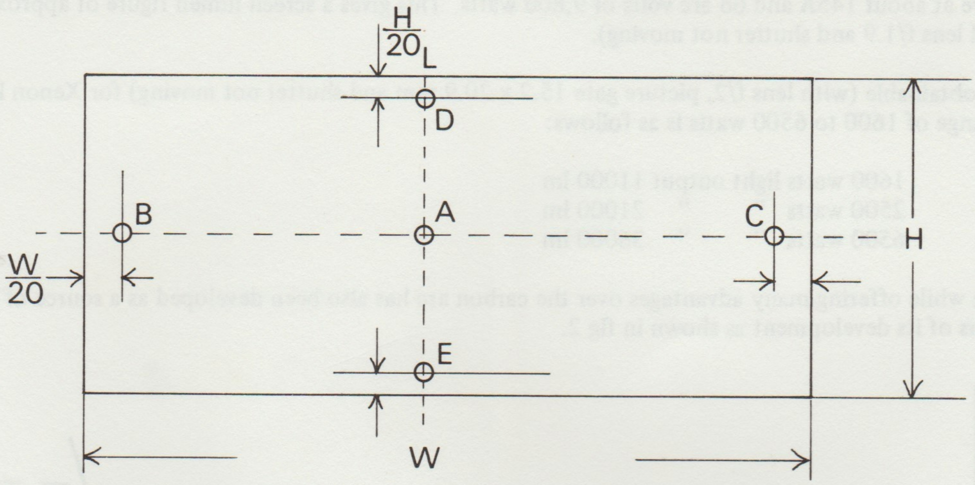


Fig.1

Measure of light intensity at the points indicated above: at points B, C, D and E it should be at least 70% of that at the centre A.

Screen brightness is measured in units of luminance, including:

a. Candelas per square metre: cd/m^2 also known as nits.

b. Apostilb: asb= $1/\pi$ cd/m^2.

c. Foot-lambert: ftL = 3.426 cd/m^2.

Example: A projector light output is 500 lumens, screen size is 3 m x 4 m = 12 m^2. Screen illuminance is 500/12 = 41.7 lux. If the screen gain is 2 (beaded), screen luminance is 41.7 x 2 x 0.3183 = 26.55 candelas/m^2 or nits or 26.55 x 3.142 = 83.4 asb and as 1 ft L = 3.426 cd/m^2 therefore 7.7 ft lamberts.

Example: A projector light output is 500 lumens, screen size is 9 ft x 12 ft = 108 ft^2. Screen luminance is 500/108 = 4.63 ft candles. If the screen gain is 2 (beaded), screen luminance is 4.63 x 2 = 9.26 ft-lamberts.

Screen brightness standards are varied and wide including:

a. 37.5 ± 3.5 cd/m^2 (11 $\pm$ 1 ftL)

b. 40^{+25}_{-10} cd/m^2 (12 ftL mean)

c. 55 ± 7 cd/m^2 (16 ftL mean)

Europe tending to a lower screen brightness and America the brightest but a realistic figure is around 12 ftL. A print graded at this figure will be reasonable on 8 ftL and on 16 ftL.

The mirror arc lamps using high intensity carbons have been used for projection since 1920.

The light flux obtainable (with lens f/2 picture gate 15.2 x 20.9 mm and shutter not moving) amounts at present to about 36000 lm for high intensity carbons and 6000 lm for low intensity carbon arc lamps.

The output to screen depends on the technical design and the optical features (rotating carbons, diameter of mirror respective to its aperture, etc) as well as on the quality of the high intensity carbons, the load limit of which is given by uneven burning rather than by too fast combustion.

Many theatres still use the conventional carbon arc lamp with a 14 in diameter silvered mirror and burning a carbon combination of an 8 mm copper coated positive and a 7 mm copper coated negative at about 65A and 43 arc volts or 2600 watts. This would give a screen lumen figure of approx 17,000 lm (with Bloomed lens f/1.9 and shutter not moving).

The theatres with the larger screens use a rotating positive arc lamp which can be loaded up to 140A or a carbon arc lamp using a 17¾ in (45 cm) diameter dichroic mirror and burning a carbon combination of a 13.6 mm positive and a 11 mm negative at about 145A and 68 arc volts or 9,800 watts. This gives a screen lumen figure of approx 24000 lm (with Bloomed lens f/1.9 and shutter not moving).

The light flux obtainable (with lens f/2, picture gate 15.2 x 20.9 mm and shutter not moving) for Xenon lamp-houses covering the range of 1600 to 6500 watts is as follows:

1600 watts	light output	11000 lm
2500 watts	" "	21000 lm
6500 watts	" "	36000 lm

The Xenon arc while offering many advantages over the carbon arc has also been developed as a source of light output during the years of its development as shown in fig 2.

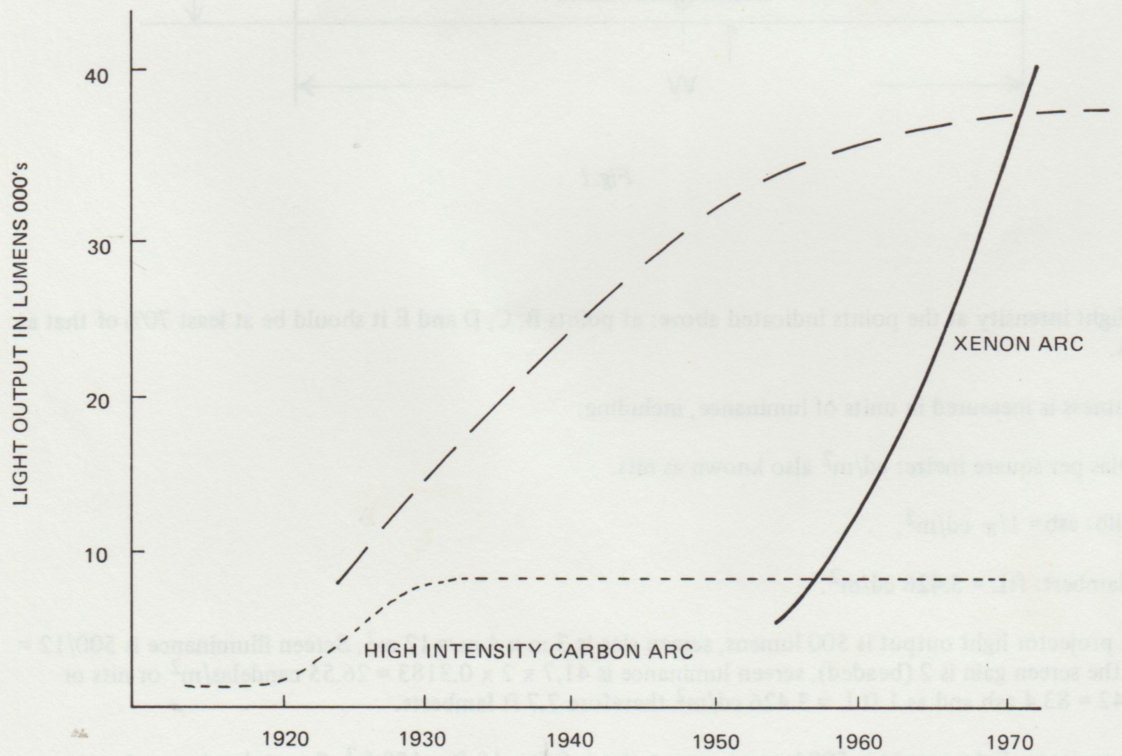


Fig.2

These curves show that for many years the xenon arc was incapable of providing the light output attainable from the large high-intensity carbon arcs. But by 1970 the xenon equalled the carbon arc in respect of the maximum light output and has made its way from the technical novelty of 1954 to a regular and highly appreciated light source.

The screen widths attainable with Xenon arc are shown below. They are shown for screen luminances of 100 and 120 asb and for 5 luminance factors of the screen:–

0.8 – 1 for white screen
1.4 – 1.8 for Perlux screen
1.4 – 2.5 for Silver screen

The screen widths are valid for objectives having a relative aperture of f/1.8 and for bulbs of medium output. The bulb output may fluctuate within ± 10% in different bulb specimens.

For objectives with a relative aperture of f/2 the screen width drops by about 10%. The values stated for standard as well as wide screen are calculated in relation to a lamp setting for optimum illumination of the cinemascope screen, assuming that this setting is maintained unchanged, also for the smaller standard and wide screen sizes.

Maximum screen widths in metres without honeycomb condenser.

	Luminance factor of the screen	Standard and Wide Screen 100 asb	Standard and Wide Screen 120 asb	Cinemascope 100 asb	Cinemascope 120 asb
900W/42A	0.8	5.5	5.0	8.0	7.0
	1.0	6.5	6.0	9.0	8.0
	1.4	7.5	7.0	10.5	9.5
	1.8	8.5	8.0	12.0	11.0
	2.5	10.0	9.0	14.0	13.0
1600W/65A	0.8	8.0	7.0	11.0	10.0
	1.0	9.0	8.0	12.0	11.0
	1.4	10.5	9.5	14.5	13.5
	1.8	12.0	11.0	16.5	15.0
	2.5	14.0	13.0	19.5	18.0

These figures indicate a luminous flux with shutter running:–

900W	normal and wide screen	3100 lm
900W	CS picture	3500 lm
1600W	normal and wide screen	5800 lm
1600W	CS picture	6600 lm

and variations of the attainable screen width with current

900W

Current Amps	25	30	35	40	42
Relative screen width %	65	75	85	95	100

1600W

Current Amps	40	45	50	55	60	65
Relative screen width %	65	73	80	85	93	100

The above relationship between screen widths percentages and operational currents will help to estimate the operational current required when covering screen widths smaller than those shown above.

Luminous factor of the screen	Standard Width in Metres	Cinemascope in Metres	70 mm Film in Metres
6500W/160A			
0.8	14	20	20
1.5	19	27	27
1.8	21	30	30

This large unit enables the Xenon arc to be used in the field of large and giant screens which has formerly been the sole purpose of the large automated carbon arc lamps.

22 LIGHT SOURCES AND LAMP HOUSES.

LAMPHOUSE MIRRORS FOR BOTH CARBON AND XENON ARCS

Care and maintenance

The lamp house mirrors are either elliptical or parabolic and together with the arc from the **Mirror Arc**.

The light from the large radiation angle from the arc crater is collected by the large concave mirror and imaged into the projector gate.

The form of the main mirror and other components in the system such as secondary mirrors, condensor lenses, etc, will be determined by the size and type of arc used.

The manufacture of the lamp house will have determined the complete design and the hand-book instructions must be followed at all times for both adjustment procedures and replacement of individual parts (components).

All mirrors have a highly polished reflecting surface to enable them to collect and reflect light rays without appreciable diffusion.

The types used are:

a. Metal mirrors in speculums metal, stainless steel, anodised aluminium or either rhodium or chromium plated.

b. Glass silvered on either back or front surface.

c. Dichroic mirrors made by coating a glass blank with multi-layer interference films instead of silver. Most of the visible light is reflected by this type of mirror whereas the infra-red is transmitted, thus reducing greatly the heat effect on the film.

The average transmittance in the infra-red region of $0.8 - 2.7\mu$ is about 80%. In comparing the performance of a silvered mirror with a dichroic or cold mirror in a carbon arc projector, the cold mirror permits the power of the lamp to be increased by approx 50% for the same heating at the film gate.

As it is generally required to operate film projectors in matched pairs it is important that the lenses and particularly the mirrors are matched for colour transmission and reflection.

Dichroic mirrors vary widely in their colour reflection so that new and spare mirrors must be carefully tested and selected for use in a pair of projectors particularly when used in conjunction with Xenon Arcs.

The following points will enable the projectionist to keep the lamphouse mirrors and therefore the screen brightness at peak:–

Check that the mirrors are correct for the lamphouse. They must be suitable in diameter, curvature and focal length.

The design constants are usually stencilled on the back of the mirror in terms of major and minor set-up distances.

Replacement mirrors must always have the same figures, because any divergence is likely to result in serious loss of light.

Make sure that the mirror holder is so maintained that the arrangements to allow expansion and contraction of the mirror are not interfered with. Mirrors get very hot and must be able to expand otherwise they will crack.

Make sure that as much heat as possible is kept away from the mirror. Poor lamphouse ventilation shortens their life – ventilation systems should be of a generous size and be cleaned out regularly.

On steep negative projection rakes, the top of the mirror may overhang the arc tail flame which can cause deterioration at the top of the mirror. Steps should be taken to deal with this problem where necessary through adjustment of the magnetic flame control and/or other means.

Mirrors on which the silvering has deteriorated and become clouded, absorb light instead of reflecting it and may overheat and crack. They should be replaced just as soon as such deterioration exceeds say 10% of the total area. Mirrors of a pair of projectors must be either resilvered or replaced as a pair in order to maintain the light and colour balance.

On modern arc lamps, mirror pitting, which is due to incandescent particles shot from the carbon crater onto the mirror surface, is no longer a problem because of the relatively large diameter and the relatively long working distances, but any mirror that shows serious signs of pitting should be replaced as this means loss of light. Again if the projector is one of a pair, then both mirrors must be treated the same.

Dichroic mirrors have very special coatings which while reflecting light allow transmission of heat through the mirror. The coatings are susceptible to damage as they are extremely thin. Mirrors of this type need extra care in handling, especially if the coating is on the inner reflective surface of the mirror.

Make sure that the mirror dowser is in good condition and in place before striking the arc. If it is a carbon arc and it is struck without this protection there is a likelihood that the projection of particles from the carbons may cause the mirror to fracture.

Whether burning-in carbons or testing the equipment, never run for any length of time at a low current. Under such conditions soot is formed and this may be deposited on the mirror. If full current is then applied, a spot of intense local heat will be developed in the glass which may crack in a very small space of time.

Make sure that the mirror is not subjected to any cool draught or sudden changes in temperature when it is hot. Otherwise there is a possibility that the mirror will crack even if it is of the so-called heat-resisting type.

Take care when fitting carbons or Xenon bulbs that the holder or cable connections do not knock against the mirror.

Metal mirrors are particularly susceptible to distortion in handling and in spite of their apparent sturdiness should be treated very carefully in this respect.

Make sure that spare mirrors are stored in a damp-free atmosphere and that any packing material is dry.

How to clean and maintain Arc Lamp Mirrors in good condition

The arc lamp mirror is an important optical component and needs to be kept absolutely clean at all times.

Great care should be taken when removing the mirror from its holder to ensure that no damage to the reflecting surface occurs around the edge or around the hole in the centre.

When removed for cleaning the convex surface of the mirror should be placed on a felt pad on a table or stood on its edge on a felt pad for cleaning in this upright position.

Where possible it is recommended that mirrors should be cleaned without removal from the mounting and without the back being handled.

Regular cleaning will help to minimise the adverse effect that the heat stream from the arc has on the mirror surface.

To clean a silvered glass mirror

The face of the mirror should be carefully wiped with a soft clean and dry cloth. This will remove soot and fume deposit and small carbon spots which if allowed to remain and accumulate will cause a loss of light.

Using a good quality cotton wool and removing a layer of wool as it becomes dirty, apply one of the proprietary mirror, optical or window cleaners of the whitening type.

Never use too much of the cleaning fluid and do not allow the mirror to become wet with free water.

When dry polish with a clean, soft and dry cloth.

To clean a dichroic or 'cold' mirror

Do not wipe the coated surface with a handkerchief or ordinary duster and avoid finger prints. Always handle the mirror by holding the edges.

Use a soft tissue paper or very soft cloth in the form of a pad. This can be dampened with a special cleaning solution obtained from the manufacturer or alcohol. Wipe in a spiral pattern from the centre out. Be sure to shift the cloth or paper frequently to avoid wiping with a dirty part. Moisture and dust are a great danger to the very thin surface coating.

Monthly cleaning should be satisfactory.

To clean a metal mirror

Take great care not to scratch the surface either with carbon holders, harsh cleaning abrasives or in any other way.

Lightly wipe off all dust with a clean, soft and dry cloth.

Apply a high grade silver polish. Never use brass or chromium cleaners as they will damage the reflecting surface of the mirror.

Any bloom caused by arc fumes may be removed with jewellers rouge and water. If the mirror is anodised aluminium the rouge should be mercury free.

23. PROJECTION LENSES

The projection lens is one of the most important items in securing good presentation. It is extremely costly and delicate and must be treated with the greatest care. Since the small frame on the 35 mm film is often enlarged as much as 500,000 times in area, the best possible optical quality of lens must be used. The design of the lens is therefore very important: it must transmit the maximum amount of light, illuminate the screen area evenly and produce a projected image which is as free as possible from spherical aberration, field curvature, astigmatism and chromatic aberration, all of which will tend to produce an unsharp or distorted picture.

Lens Aperture

A lens is characterised by two factors: its focal length and its aperture, sometimes referred to as its "speed". Its aperture indicates the angular size of the cone of light which the lens will pass and is normally specified by its "f" number, the ratio of the focal length to the diameter of the front exit surface of the lens. Thus a lens of focal length 6 inches with a front element 3 inches in diameter will be designated f/2, as will also a 4 inch focal length lens with a diameter of 2 inches.

The greater the cone angle of a lens, the more light it will be able to pass and the f number is therefore an indication of this ability: the smaller the f number, the greater the light passed. The light transmitted by lens of different apertures is proportional to the reciprocal of the square of the f number, so that a lens of aperture f/2 will pass four times as much light as one of aperture f/4. Projection lenses usually have aperture values of f/2 or better, f/1.8 being often available. The light transmission of a f/1.8 lens is some 23% greater than that of a corresponding f/2 lens, so the improvement is quite appreciable.

Unlike lenses used in cameras, a projection lens is always operated at its maximum aperture and there is no adjustable diaphragm to vary the amount of light transmitted: in projection, this adjustment must be done by varying the voltage or current of the arc-lamp light source.

Focal Length

The focal length of a projection lens determines the size of picture which will be obtained at any particular distance from projector to screen, (the throw), and is therefore a primary factor in the choice of lens for a given theatre. The focal length will always be clearly marked on the lens barrel and for motion picture projection the available focal lengths usually range from 2 inches up to 6 inches, in steps of one-quarter of an inch, or from 50 millimetres up to 150 mm, in steps of 5 mm.

To decide upon the focal length required for any particular cinema, we can use the following formula, in which we need to know the **throw**, that is, the distance from the projection lens to the centre of the screen, the **width** of the picture to be projected on the screen, and the width of the film **frame** in the projector gate, which is standardised at 0.825" for normal wide-screen presentation. Working in feet and inches, the formula is

$$\frac{\text{Throw, in feet} \times \text{Frame Width, in inches}}{\text{Picture Width, in feet}} = \text{Focal length in inches}$$

If we are working in metric units, we must measure the throw and projected picture width in metres and the width of the frame in the gate in millimetres. Here the standard for wide screen showing is 21 mm. The formula is then

$$\frac{\text{Throw, in metres} \times \text{Frame Width, in mm}}{\text{Picture Width, in metres}} = \text{Focal Length in mm}$$

In the case of anamorphic projection, the width of the Cinemascope frame at the projector gate is 0.839" or 21.3 mm, but because the anamorphic projection lens doubles the width of the picture on the screen, we must take only half this width, 0.4195" or 10.65 mm for our calculations.

The same formula can also be used to find the width of picture which will be projected with a given focal length lens at any particular throw, or the throw necessary to fill a particular screen width.

Anamorphic Projection Lenses

In Cinemascope prints the picture image is compressed laterally ("squeezed") at the time of the original photography and must be correspondingly expanded on projection. Anamorphic projection lenses do this by enlarging twice as much horizontally as they do vertically, so that they are said to have an expansion factor of 2.

There have been many types of lens design to produce this result, some embodying prisms or complex mirror surfaces, but the modern type is one which makes use of a number of cylindrical glass lenses and has good light transmission, freedom from colour aberration and uniform magnification across the width of the screen.

Anamorphic lenses may be either a complete projection lens unit or an attachment to be mounted in front of a normal projection lens, which is then termed the backing lens. Such attachments can be screwed into the front of the backing lens or can be carried separately on a turret mount in front so that they can be swung into the optical path when required.

When using an anamorphic attachment it is essential that it should be very accurately aligned and focused and a test film containing well defined horizontal and vertical lines in a clear pattern of squares or rectangles should be used. Specially designed Anamorphic Picture Alignment Test Films are available. When setting up, procede as follows:

1. Swing the anamorphic attachment into position in front of the backing lens with its projection distance index set to infinity.

2. Check that the projected lines of the test are correctly vertical and horizontal, even though not completely sharp. If there is any skew distortion, rotate the anamorphic attachment until it is corrected.

3. Focus the backing lens to obtain sharp images of the horizontal lines.

4. Then focus on the vertical lines using the distance setting of the anamorphic attachment.

5. With both vertical and horizontal lines sharp, re-check the squareness of the projected pattern.

The Care and Maintenance of Projection Lenses

Scratches, dust, finger-marks and oily deposits on any surface of a lens scatter the light and impair the contrast and definition of the picture.

All modern projection lenses are "bloomed", that is, their surfaces are coated with a thin layer which improves their light transmission and reduces flare. This layer is only 4 or 5 millionths of an inch in depth and although comparatively tough it needs handling with great care to preserve its properties. If oil spots or finger-prints are left on the surface too long, they can cause permanent damage and the lens may have to be sent back to the manufacturers for re-polishing and re-coating.

A good projectionist will always keep a soft camel-hair brush and a packet of lens tissues readily available for the care of his lenses.

Lenses should be cleaned at least once every day. They should be cleaned before commencing the day's programme and examined after the last performance so that no mark remains on them all night.

Never wipe a lens with a cloth. The lens should be dusted with a soft camel-hair brush or a lens tissue. Keep the brush in an airtight container and if it becomes soiled or greasy wash it in ether and let it dry naturally.

If the lens surface becomes greasy apply a **little** medical spirit on a tissue. It is very important that the spirit only dampens the tissue. Free spirit on the lens surface could enter the lens barrel and impair the blackened surfaces causing internal reflections and loss of image contrast.

The lens should never be dismantled – the assembly of a lens needs special test equipment at each stage of the process of pairing and matching.

If there is an internal defect send it to the manufacturer for correction.

It is a good practice to use the lens caps originally provided when the projector is not in use. If they are not available get them from the manufacturer.

Although the projection lens is the most critical item in the projectionist's care, the condition of the port-hole glasses can also detract from good presentation if they are dusty or smeared. Both surfaces of these should be frequently cleaned, firstly with a soft clean cotton handkerchief or similar material that is free from lint fibres, and finished off with a lens tissue. If there are serious deposits, a drop of methylated spirit on a separate cleaning cloth may be used to start with. Layers of soot or smoke particles should never be allowed to build up on the port glasses but should be regularly removed.

24. THE SLIDE PROJECTOR

The projected slide, although little used now, is the only rational means of making an emergency announcement and can be inserted into the programme almost immediately.

British Standard B.S. 1917 issued in 1968 sets out in detail in Section Five the dimensional tolerances, projection area and preferred method of position indication.

Slides are obtainable packed in boxes of twelve from the accessory dealers or directly from the manufacturers.

Those intended for emergency announcements have a patented ruled area on the surface so arranged that the writing will conform to the screen area – this guide makes it possible to keep the wording straight and of consistent height, thus allowing good presentation. They have a matt grey surface which is easily cut with a scriber or any pointed object.

Slides can also be obtained with pictorial or geometric designs thereon, in either black-and-white or colour, to give pleasing effects.

When designing, selecting or ordering special slides consult the slide maker. The aspect ratio of any screen can easily be reproduced on the slide and the slide maker will be pleased to have this information. With lenses of the correct focal length a more proportionate and pleasing effect can be obtained rather than the "postage stamp" size slide image often seen on to-day's large screens.

On projection throws with steep rakes inform the slide maker of the angle involved. He can then design the layout of the slide to minimise any "keystone" effect by avoiding the use of long vertical lines especially when such lines are near to the edge of the slide.

Photographic emulsion type slides should be stored in a warm dry atmosphere and if possible the slides should be warmed up before projection. This helps to avoid moisture in the emulsion condensing during projection which can occur when the slides are new and perhaps "green".

Size and composition of the subject matter for a slide should be carefully planned. Brevity of "copy" is of paramount importance – fine lines and small type should be avoided.

Always remember to clean regularly all slides and slide projection equipment as only clean and well maintained components will give good presentation.

Unlike the film projector, a slide projector seldom has reflector optics, but nevertheless deterioration of picture can be due to:

1. Poor lamphouse ventilation.
2. Clouded and fumed condenser-lenses.
3. Discoloured condenser-lenses due to overheating.
4. Clouded projection-lens.
5. Carbon misalignment.
6. Incorrect focusing of crater in relation to condenser lens.
7. Pitted condenser-lenses due to particles from carbons.

The regular cleaning of condenser-lenses ensures maximum efficiency from the slide projector. Use great care in removing mounting and lenses from the lamphouse and ensure that lenses are refitted in the correct position.

Apply over the surface a "whitening" type of cleaner, rubbing well where fume deposits are noted. Allow cleaner to dry and then polish off with a clean dry cloth.

Slide projection-lenses should be cleaned in accordance with information given in the preceding Section on the care of lenses.

Slide projectors using projector-lamps instead of carbon arcs as the illuminants should have their lamps, and reflectors, cleaned regularly.

The stationary position of the slide and its carrier in the light beam necessitates an allowance being made for expansion due to the heat of the beam, so slides and carriers should always be free running in their guides.

A number of types of heat filters are used in slide projectors to divert a large proportion of beam heat from the slide and the cleaning and maintenance of these filters should be carried out in accordance with the manufacturer's instructions.

25. AUTOMATION IN THE CINEMA

Programme automation will not do the projectionist's job for him but it is a wonderful assistant which will enable him to put on a perfect show. The projectionist's tasks in dimming house lights, striking his arc or xenon lamp, fading out the soft music, fading in the sound on film, framing, opening the curtains, adjusting screen masking and checking focus, making good change-overs – every one of these if not performed to the second can spoil a show.

By means of a programme automation all these functions can be carried out with perfection **and with identical perfection** during the remainder of the week – or the duration of the particular programme set-up. If a slight error is made in his first programme timing it can be corrected for the next and thereafter the projectionist's mind is relaxed and he is confident in giving his attention to the finer points of film presentation. The exhibitor or manager too can go about his multifarious other duties in the theatre in peace of mind. Automation, too, enables a chief projectionist to run more than a single show – Fig. 1. shows a typical multi-cinema installation of such a situation.

A TYPICAL MULTI-CINEMA CONVERSION

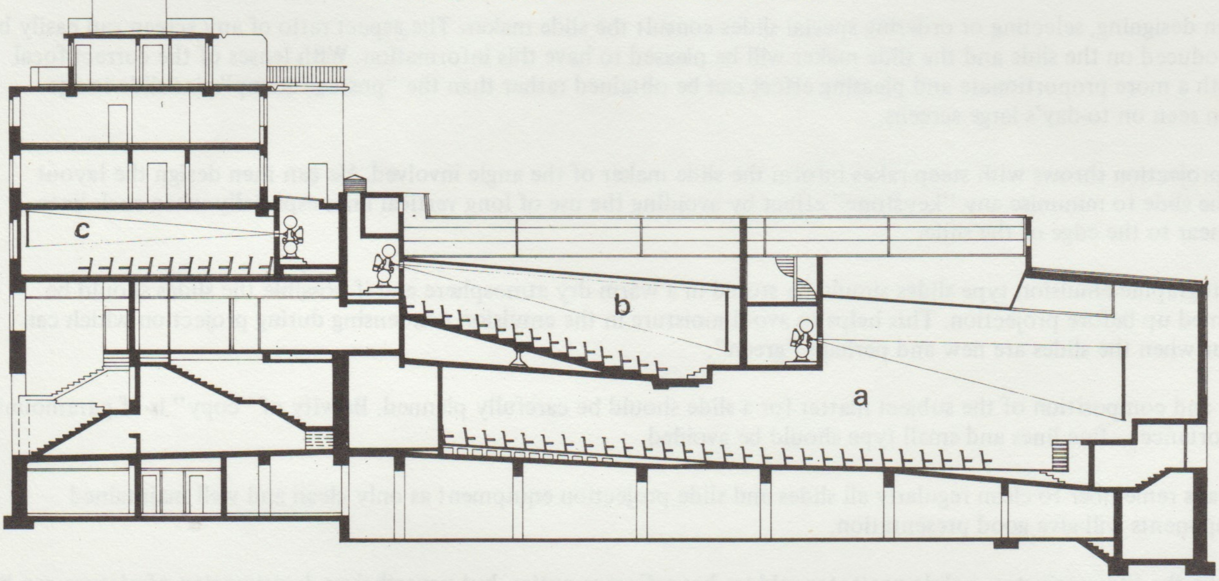


Fig.1

(a) The Rex Cinema, 381 seats, screen 10.5 x 4 metres with two Cinemeccanica 8 automatic projectors.

(b) The Filmstudio Cinema, 212 seats, screen 7.5 x 3.4 metres with a single Cinemeccanica Victoria 8 automated projector.

(c) The Princess Cinema with 79 seats, screen 7.5 x 3.4 metres with a single Victoria 9 automated projector with the DGB 2 x 4 long playing device.

Automation can be applied to a few functions or to all the functions of projection. All systems include a "fail-safe" device which shuts down projection if the light source fails, the film breaks, or the projector slows down or the mains electricity supply fails.

The various functions are performed either by a timing device or by placing small adhesive metal foil tabs on the edge of the film which are detected and a signal passed to the actuating equipment. Some of these systems and the associated long-playing equipments are described elsewhere in this manual.

The responsibility of the projectionist is increased rather than lessened by automation. The pre-programme work in preparing and joining his film into large – perhaps 13,000 ft – rolls, in cueing the rolls and arranging his diode pins and so on, is more painstaking and arduous than before but is rewarding too.

The installation of automatic programming in a new or a rebuilt cinema is comparatively simple since the cables and wires for the various functions can be laid to the central point at once.

The conversion of an established cinema is more difficult but all cinemas no matter how simple can take a considerable degree of automation provided that the apparatus is in really good condition.

26. AUTOMATION DEVICES

Automation related to 35 mm sound film projection techniques in cinemas ranges from a simple safety device which will stop the projector in the event of a mishap, to a system which will control a performance simply as the result of a button being pressed or a timer being set.

Combined with a long-playing device these systems can control the whole programme from Theatre opening to closing.

The Westrex/Cinelogic and the Essoldomatic Cinemation series of automated systems are typical of the complete range referred to above. These systems can be adapted for use with all the better known types of projectors/sound equipments.

THE WESTREX CINELOGIC SYSTEMS

System B monitors the light source and that the film is intact and the projector is running at a safe speed.

The system will disconnect all the principal units from the power supply in the event that:

1. The light falls below a predetermined level, or
2. The projector runs at significantly less than its correct speed, or
3. The film breaks, or
4. The main supply fails.

An LDR (Light Dependent Resistor) is placed in the projector in such a manner as to be activated by the light beam from the Xenon or arc lamp. The presence and rate of passage of film is detected by a tachometer fitted to a film driven idler roller.

An integrating circuit in the control unit converts the output from the tachometer to a voltage proportional to the film speed. An indicating lamp shows that it is safe to switch the system into operation after the projector has started, thus avoiding unnecessary interruptions to the performance.

System C This system includes the facilities provided by System B but additionally provides for automatic changeover from one projector to the other. Information to instruct the incoming machine to start, is derived from a small piece of metal foil attached to the sprocket hole area of the film which is detected by a sensor fitted to the projector.

System D This system provides complete automation in the cinema.

The following sequences and functions are provided for:

	Function	Action
1.	**Theatre Open**	Curtains closed, decorative lighting raised, auditorium lighting raised, background music started, pre-programme interval timer started.
2.	**Start**	Auditorium lights dimmed, decorative lighting dimmed, projector and Xenon lamp started, curtains opened, background music faded down, light dowser opened, film sound faded up.
3.	**Format Change**	This feature is only available with projectors which provide for motorised lens turret and aperture plate change, (e.g. Westrex 7000) Motorised masking changed.
4.	**Interval**	Curtains closed, sound faded from film to background music, decorative lighting raised, auditorium lighting raised, interval timer started. The restart sequence at the end of the pre-programmed interval is the same as for the start of programme.
5.	**Stop and End**	This action is the same as for interval stop, except that the interval timer is not started.

System Mini D A simplified model of System D above, intended for single projector installation where partial automation is required.

The unit is self-contained and cannot be used with other units within the range. Automatic cut-off protection provided within the unit.

		Function		Action
a.	1.	**Auto-Start** When initiated by local or remote push button, or by optional local or remote interval timer unit, controls the following sequence	1.	Motor on lamp on.
			2.	Protection circuit "In". If film on speed and lamp on, sequence continues. If not, units perform same functions as C below.
			3.	Auditorium lighting dimmed.
			4.	Shutter open, sound to sound on film, background music off.
b.	2.	**Auto-Stop** (Intentional) When initiated by local push button or by film edge foil marker, controls the following sequence.	1.	Screen curtains "Close" decorative lighting "Raise", background music drive motor on.
			2.	Shutter close, sound to background music, auditorium lighting raise.
			3.	Projector motor and lamp off.
c.	3.	**Auto-Stop (Emergency)** If the film goes under speed or lamp goes out during projection, controls the following sequence.	1.	Dowser "Shutter" close, lamp off, motor off, background music on, screen curtains close, decorative lighting raise, alarm bells on.
			2.	Auditorium lighting raise (optional).

All the above systems are available with local and remote warning, audible and/or visual. This warning indicates that a function has been carried out or that there has been an un-scheduled stop to the performance.

A typical block diagram of a Cinelogic System is shown in Fig. 1.

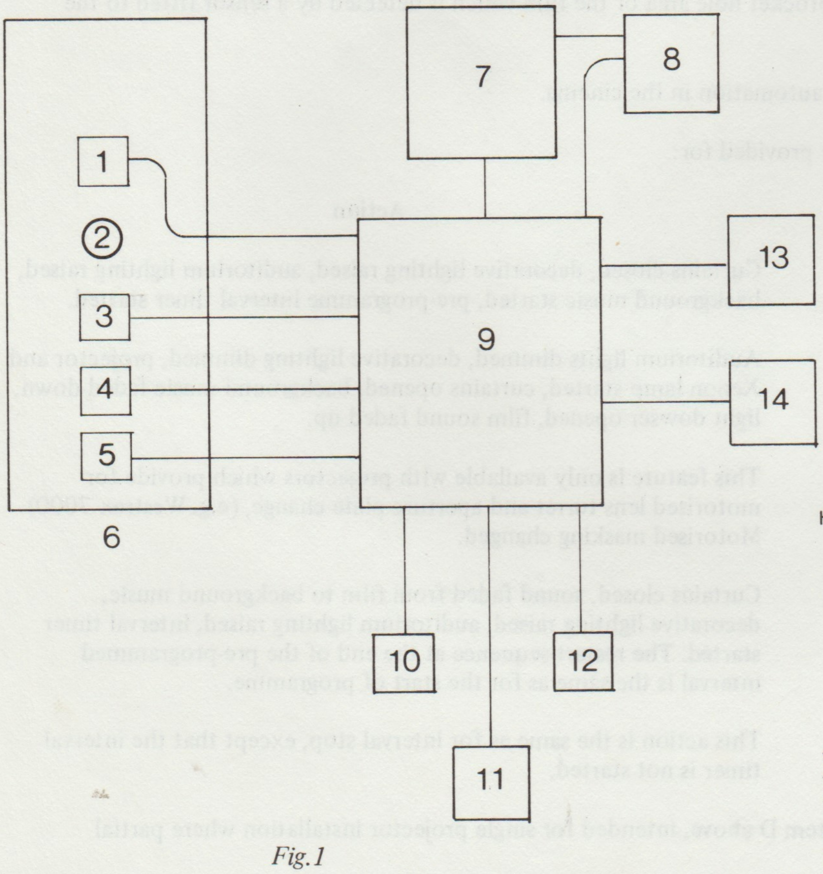


Fig.1

KEY
1) LDR Sensor for arc or Xenon lamp
2) Tacho. Sensor for film motion
3) Film coding sensor for functions
4) Projector motor switch
5) Arc or Xenon lamp control
6) Projector assembly
7) Sound amplifier
8) Tape cassette player
9) Main control
10) Start timer
11) Remote audio/visual warning for projectionist
12) Remote start control
13) Dimmer, auditorium lighting
14) Controller stage tabs

The current range of Cinemation Automatic Control Systems comprises four models as follows:–

Cinemation MK IV

A flexible system designed for two projector operation and offering automatic changeovers of picture and sound and automatic control of all normal presentation functions, including curtains, masking, non-sync. decorative and house lighting, etc.

The equipment is programmed by inserting diode pins into a 48 x 15 way Matrix, which is progressively scanned when a pulse is received from a mark of self-adhesive metal foil affixed to the film. A proximity detector is positioned close to the film and detects the presence of the metallic foil affixed to the film.

This modern method of detecting the marks on the film does not rely on contact with the film, thus removing the hazard of film damage.

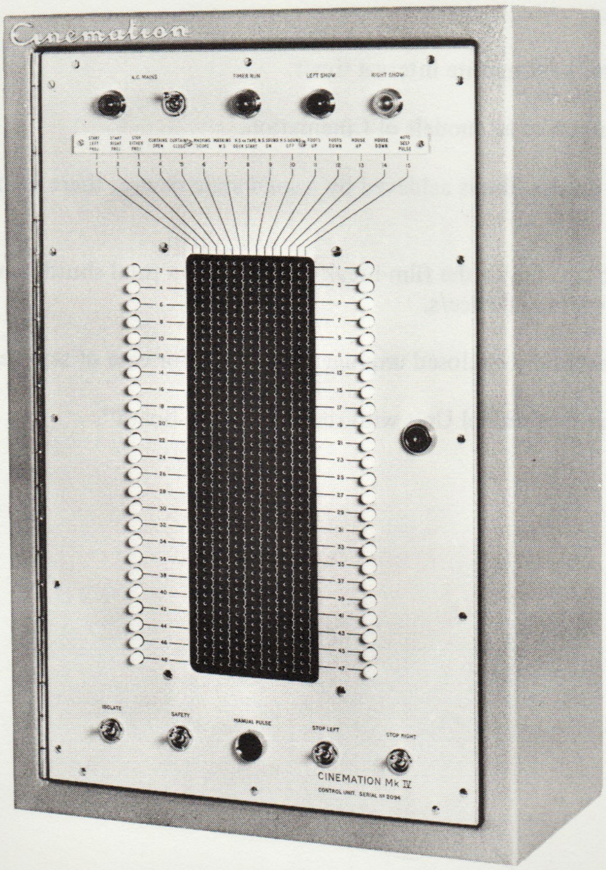


Fig.2. Cinemation Mk IV Control Unit.

Cinemation MK 12

A simplified version of the MK 4 inasmuch that no programming Matrix with diode pins is used, the equipment offering control of the same functions as the MK4, but on pre-set sequence operations comprising:–

a. The starting of the show sequence.

b. The changeover between projectors of picture and sound sequence.

c. An interval sequence.

d. An end of show sequence.

Additionally, this model incorporates an in-built 60 minute interval timer, so that automatically timed intervals can be initiated together with automatic re-start of the show when the interval has been timed out.

Cinemation MK 10T & MK 10

This model is designed to operate in conjunction with a single projector, together with a long play film handling device. It is fully compatible with all makes of 'cake stand' or film platter systems, also all makes of vertical tower film handling devices.

Cinemation MK 10T offers the following automatic control functions:–

a. The starting of the show sequence.

b. The starting and stopping of the projector and Xenon lamp.

c. The switching of the sound from non-sync to film sound and vice versa.

d. An interval or alternatively a decorative lights up/down sequence with or without masking and lens change functions.

e. An end of show sequence.

The Mark 10T also incorporates a 60 minute interval timer.

The following feature are common to all models of Cinemation.

1. The detection of marks on the film is achieved by a solid state device, there being no physical contact with the film.

2. Should either the light beam fail or the film break or run slow, a total shutdown will occur together with the sounding of an audible warning device/s.

3. All relays used are of the totally enclosed unpluggable variety for ease of service.

Fig. 2. shows a typical Cinemation Control Unit with its matrix "pin-board".

27. KEEPING AN EYE ON THE SOUND

Introduction

Audio reproduction is no longer the esoteric black art which it once seemed, and every projectionist has some familiarity with the basic constituents of a simple sound system. These may be summarised as the reproducer, the amplifier, the volume control and the loudspeaker. We shall not dwell on first principles, but consider the peculiarities of a cinema sound system.

The Reproducer

Film sound tracks are either photographic or magnetic, the former being by far the most common. They are scanned by the motion of the film through a soundhead. Photographic tracks are thus caused to vary the quantity of light transmitted through a minute length of the track, and this light falls on a photoelectric device. The track may vary along its length either in transparency or (more usually) in the relative width of the clear portion (variable area.) The resulting fluctuations of light on the sensitive surface of the photoelectric device produce changes of either electrical resistance or generated current (according to the type), so that the audio signal then takes electrical form.

It is useful to note that optical scanning systems are of two basic types. In one, the light from an exciter lamp is focused on a slit-shaped aperture, (Fig. 1) and this is in turn imaged by a lens on to the film as a very fine illuminated line, perhaps 0.025 mm thick, across the strip of film occupied by the soundtrack. The light emerging from the back of the film is directed to the photosensitive cell. In the other system, the condensed light from the lamp illuminates an area of the soundtrack as it passes through the soundhead, and this area is projected in sharp focus on to a plate bearing a slit-shaped aperture in front of the cell. (Fig. 2)

FRONT SCANNING OPTICS

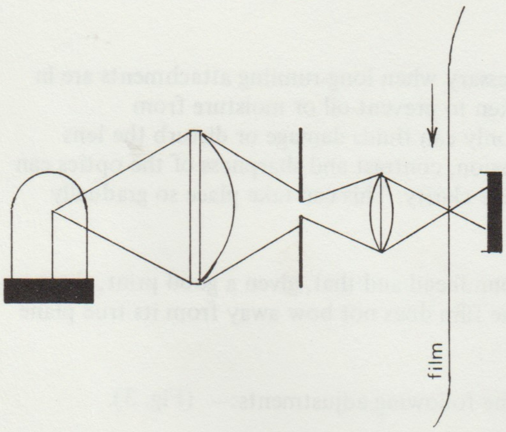


Fig.1

REAR SCANNING OPTICS

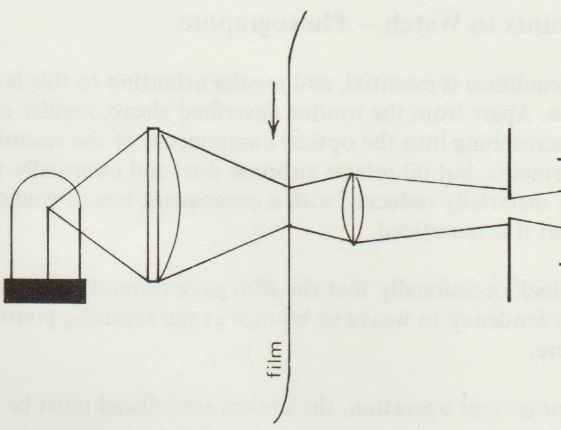


Fig.2

A magnetic soundtrack is to be compared with a magnetic tape, and the principles involved are identical. Scanning is effected in a soundhead above the intermittent mechanism, and this is commonly referred to as the penthouse. As in a tape recorder, the passage of the magnetic track over the gap in a ferric core causes a varying flux to appear in the core. There is a coil of many turns wound on this, and an alternating current is induced in the coil by the changes of flux in a similar manner to the action of a transformer. On film it is usual for there to be several channels for stereophonic reproduction, and in order to make the best use of the space available on the print these are distributed over four separate stripes of magnetic coating, which are applied after the picture image has been printed, processed and dried.

The ear is remarkably sensitive to changes in the pitch of sound, so that it is vitally important for the film to pass the scanning point in the optical or magnetic soundhead at a perfectly constant speed. Failure in this respect leads to the effects familiarly known as wow and flutter, according to the rapidity of the fluctuations. Both are unpleasant and out of place in a theatre. The designer of the soundhead incorporates a smooth, carefully-machined drum round which the film passes at or very near the scanning point. The film is under tension here, so that once up to running speed it grips the drum (aided in some designs by a pressure roller) and its linear motion is thus determined by the momentum of the drum. A very heavy flywheel and top quality bearings on the drum shaft ensure smooth unvarying rotation.

Points to Watch – General

The film tension referred to above is frequently applied by a sprung roller, and if this is fitted with a damping device, such as a pneumatic or hydraulic dashpot, this must be maintained in good order for the stabilising system to be effective. Any dashpot oil used must be of the type and grade specified by the soundhead manufacturer, and kept at the indicated level.

The rotation of the scanning drum (or drums) must be totally smooth and quiet, and should continue for at least one or two minutes after the film has run out, the pressure roller being lifted clear. All idling rollers in the soundhead should be perfectly free, and regularly lubricated as the maker recommends. Persistent lack of smoothness will necessitate the replacement of the bearings. Remember that troublesome sticking of a roller may not be noticeable if it is tested with too much finger pressure. Look for bright patches on free-running rotating parts – they may indicate that film rubbing took place whilst the roller failed to turn.

Ahead of and following the scanning mechanism are sprockets, which serve to hold the film tension and to isolate the scanning point from uneven motion in the feed, intermittent or take-up sections. (Sometimes there is only one such sprocket, the film meeting it twice.) The sprocket teeth should be inspected from time to time with a magnifying glass to ensure that they have not become undercut, or "hooked", by film wear. This defect causes the film to engage and leave the sprocket in a jerky manner and so to contribute to flutter in the reproduction.

It is sometimes overlooked that there are start marks (gate marks) for picture and sound, and care should be taken to ensure that both are correctly centred when lacing the projector. Faulty synchronism can be very irritating to an audience.

All rollers, sprockets, guides and drums should be cleaned frequently to prevent the accumulation of dirt. On the scanning drum this produces an eccentricity which is plainly audible as wow. No part of the projector must be allowed to scratch the soundtrack: the result on photographic sound would be a progressive increase of noise, often with the introduction of distortion. Scratching of a magnetic track would accelerate the build-up of coating material and the wearing away of the track itself.

Points to Watch – Photographic

Cleanliness is essential, and regular attention to this is all the more necessary when long-running attachments are in use. Apart from the routine described above, regular care should be taken to prevent oil or moisture from encroaching into the optical components of the scanning system. Not only can fluids damage or disturb the lens elements, but oil retains airborne dust and eventually the light transmission, contrast and sharpness of the optics can be materially reduced, with a consequent loss of sound output and treble clarity. This can take place so gradually that it is unnoticed.

Check occasionally that the film passes smoothly through the whole soundhead and that, given a good print, there is no tendency to weave or bounce at the scanning point. See also that the film does not bow away from its true plane here.

For correct operation, the optical soundhead must be properly set in the following adjustments:– (Fig. 3).

1. Focus.
2. Slit azimuth (i.e. rotational position).
3. Slit length.
4. Lateral position.
5. Evenness of illumination.

SLIT ADJUSTMENTS

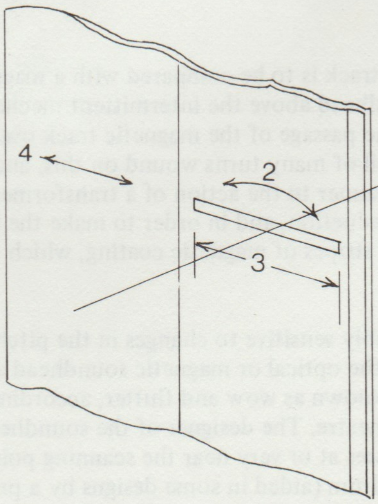


Fig.3

There is no other satisfactory method for getting these adjustments right than the use of an original test film and an output meter. O. and 2. require a high-frequency, high-level recording made for the express purpose (focus and azimuth test film), whilst 3. and 4. are optimised using a "buzz track". The latter carries tones only just outside the true track area, (Fig. 4 Left), which are audible when the slit is incorrectly set. These two types of test film may be purchased combined together, and this is a worthwhile time-saver.

TEST FILM TRACKS:
(left) buzz track
(right) slit illumination

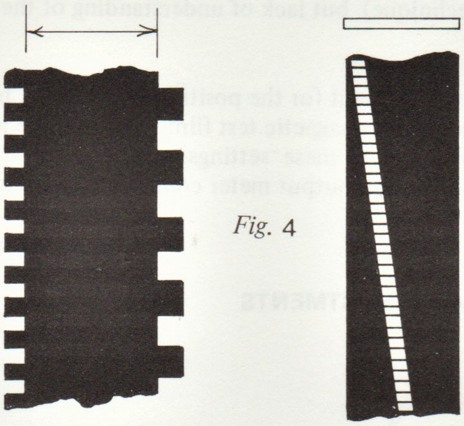


Fig. 4

The slit illumination test film moves a tiny track laterally along the slit, (Fig. 4, Right) and an even light secures constant output during this scan. Uneven illumination produces distortion on the variable area type of track, but is often ignored. Lateral and fore-and-aft adjustment of the exciter lamp is required to correct a faulty condition, and its vertical position must also be checked to ensure that maximum light is being used. If the photocell head amplifiers are provided with gain controls, there may be no adjustment for exciter lamp current. But if such a control is available, check that the maker's recommended current is being used; otherwise use the lamp controls to produce the same measured sound output level from the same level-test film.

Modern solid-state photocells are highly reliable, but earlier types sometimes display loss of output or of accurate frequency response with increasing age, and their replacement should not be overlooked as a possible cure for such troubles. They can also give rise to interfering noise in the form of crackling, sharp clicks or hiss.

Newer Photographic Sound Systems

In the Dolby SVA system, two narrow stereo soundtracks are laid down in the space normally occupied by the conventional track. The appearance is very similar to an ordinary monaural four-edge track, and differences between the two halves are only noticeable to the eye when the use of stereophonic placing is heavier than average. A very small dual silicon cell is placed a fraction of a millimetre behind the slit-illuminated film. The dead space between the two cells is carefully aligned with the septum separating the two stereo halves of the soundtrack, thus confining each signal to its own channel. A wall-mounted matrix unit subsequently re-establishes a third channel in the centre of the screen using information derived from the left and right channels, and means are also incorporated for extracting a surround signal, where this has been encoded into the original recording, to feed the ambient loudspeakers distributed around the walls or ceiling of the theatre. The same cell outputs can be combined to afford normal reproduction of a conventional monaural soundtrack. All the necessary electronic devices are housed in a simple-to-operate cabinet which includes the necessary switching. Houses fitted with the earlier 364 type of Dolby unit cannot, of course, produce stereo sound from an optical track without one of the SVA equipments, but will reproduce an SVA soundtrack monaurally.

A system of discrete multi-track stereophonic optical reproduction is being launched which does not employ any conventional photoelectric device, but instead uses a charge-coupled array to scan at a very high rate laterally across the soundtrack area, which is illuminated by a tiny integral-lens lamp. The array and the complex electronics associated with it determine the instantaneous positions of the four track edges, and thus produce outputs which are true analogues of the waveshapes traced for each channel on the film; these signals, because of the statistical approach used in the electronic processing, are highly resistant to the spurious effects produced by grain, dirt, scratches and film joins. As with Dolby, a form of complementary volume compression and expansion is used to improve further the ratio of noise to signal, but the method used here is based on DBX technology, which is claimed not to require careful adjustment of level to ensure satisfactory operation.

A unique feature of this proprietary system is that the added equipment requires no operator attention. Once set up correctly, any maintenance is carried out by the replacement of complete modules. It is stated that routine correction of track level balance is achieved automatically, the device will compensate for variation or unevenness of illumination, and weave is eliminated electronically by continual reference to the position of a minute central track which can also be utilised to provide a very large number of coded signals controlling any desired presentation functions, from screen curtains to special effects.

Points to Watch – Magnetic

The problems concerning smooth film motion are similar to those affecting photographic reproduction. But there are no comparable optical components and adjustments requiring attention; instead it is the precision with which the magnetic head poles meet the invisible tracks recorded on the magnetic stripes which determines the performance obtained. At its best, magnetic reproduction can be excellent (possibly only surpassed by the most recent developments in photographic technique), but lack of understanding of the special nature of the magnetic reproducer can lead to inferior results.

Many projectors offer no adjustment for the position of the head, but where such movements are available the head must be set up using a recognised magnetic test film. It is movable in the directions shown as A, B and C in figure 5, and should be locked off in each of these settings so as to produce a maximum peak of output from a high-frequency recording (azimuth film), using an output meter connected to the loudspeaker terminals of the centre-channel amplifier.

MAGNETIC HEAD ADJUSTMENTS

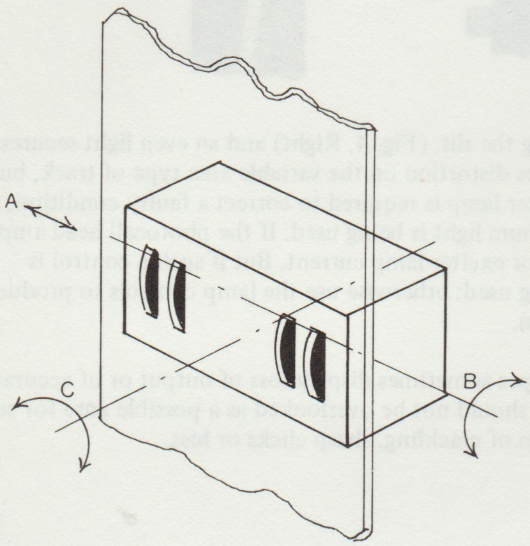


Fig.5

CONNECTIONS FOR PHASE CHECKING

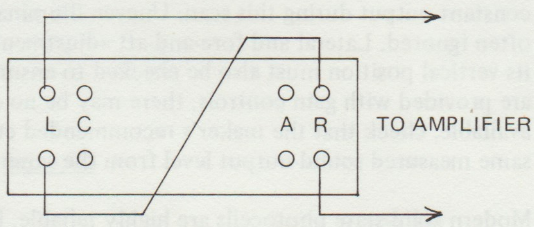


Fig.6

If it is possible to reach the head or head amplifier terminals without difficulty, a sensitive method for determining the best setting for azimuth C is to connect the outside heads in series temporarily, and adjust for maximum peak in the combined output – this will ensure that their signals are reproduced in phase. (Fig. 6). It is most important that all channels should be wired identically throughout the system in order to preserve consistent phase between them. The relative phase of the individual heads may be verified either with an oscilloscope, or by connecting them in series in pairs, and checking that shorting out each head in turn causes a drop in output; a low frequency recording should be used for this.

The polepieces of magnetic heads should be inspected regularly. Examination using a hand magnifier and bright, diffuse light should show even and equal wear of the pole faces by the magnetic coating, and tight gaps with no cavities beside the spacing shims. Any build-up of coating material on or beside the polepieces should be removed each time the penthouse is laced. A finger-tip, matchstick (the plain end!) or fine rag moistened with low-solvency cleaner, such as methylated spirit or proprietary head-cleaning fluid, may be used according to the hardness of the pack. Accumulated coating dust should be scrupulously removed from all parts of the projector, not forgetting the narrow spaces behind rollers and sprockets.

A demagnetising tool should be used frequently to eliminate permanent magnetism from iron and steel parts throughout the film path, which otherwise causes excessively noisy sound. The most convenient form for this tool is a coil of several turns of very thick wire inserted into the collets of an instant-head soldering gun in place of the loop bit supplied. This coil, when energised and gradually withdrawn from a position surrounding a steel shaft or sprocket, will leave it with no residual magnetism. To deal with the heads: if they are removable, a bulb tape eraser is very effective – otherwise use the coil (but switch off all amplifiers first.) All steel tools should be thoroughly demagnetised before use on a projector with magnetic heads. The subject of magnetisation is discussed very completely in the information booklet on CinemaScope published by Twentieth Century Fox.

Test films for the adjustment of level and frequency response in magnetic film systems are available and represent the only proper way of setting the electrical trimmers in the head amplifiers. Avoid the temptation to tweak the system using these controls, and remember that professional equipment requires professional methods.

Other Equipment

The detailed discussion of fader and amplifier maintenance is beyond the scope of this chapter, but it should be mentioned that the poor old loudspeaker, away behind the screen there, ought to be looked at from time to time. In a full set of "horns", it is possible for, say, one of a pair of bass units to become open-circuit or to have its cone damaged by mice without the effects being noticed. The assumption is that a fault has developed elsewhere to cause a lowering of bass response. Go and check that all units are working, and that every screw and nut in the assembly is fully tight. If an oscillator is available, sweep through the whole audible range gradually whilst listening in the auditorium – you may be in for a shock! Ensure that no masking or damping material covers the front of the high-frequency horns, but heavy felt or cloth draped around the rear of the speaker set is usually beneficial. In fact, the more acoustically dead the back-of-screen space can be made, the better.

The Importance of Good Projection Practice

It is sometimes not fully realised how much care and effort goes into producing the soundtrack on your current copy. Several weeks or months are taken up by a crew of dubbing editors to prepare the material – dialogue, music and sound effects. Then a period of from a week to three months is occupied by the mixing operation. Sometimes as many as a hundred edited tracks are combined, in stages, to make a finished sound sequence. The equipment used is very costly and maintained to exacting standards; the conditions used for listening are carefully matched to those found in good cinemas; the artistic and technical skills employed in the dubbing process are acquired through many years of experience and of evaluating the final results in public cinemas. The constant aim is to create a product totally suitable for its artistic and commercial purposes – it is approved by the film's producer and its distributor.

Attempts are being made worldwide to agree on standards for sound quality in cinemas, and methods of measurement. Theatres have to rely on engineers who possess the necessary electro-acoustic measuring equipment and/or experience to determine the correct adjustments of equalisers or tone controls. If a cinema has a good sound system properly operated and maintained, it should be quite unnecessary for its staff to make attempts to improve the sound quality of a good print made from a negative from a good studio. This is especially true of volume range: find the right fader setting – then leave it alone!

A good sound print, however can be ruined by careless handling and badly-maintained equipment. Dirt, sharp edges, oil, badly-made joins are common causes of damage which can destroy for all subsequent audiences the illusion designed to transport them for the moment into a new time and place. They have paid their money – they are entitled to the **best**. Consider also the producer: he has spent a vast fortune to end up with a few reels of film. He too is entitled to believe that those reels will be treated with respect, and will be presented with painstaking attention to good practice.

At its up-to-date best, cinema sound can be an experience, lifting the visual image right out of the screen to engulf the audience. It should never be allowed to decline to the point where its defects interfere with their entertainment.

28. A SUMMARY OF GOOD PRESENTATION

Your job as a projectionist is presenting motion pictures to paying customers: it is their money passing through the box office which pays your wages and keeps the cinema industry alive. People pay to go to the cinema to be entertained and they expect value for their money, a good performance, or they won't come back for more. They have a right to see a picture that is clear, bright, steady and unblemished and to hear sound that is intelligible, neither too loud nor too soft, and free from unwanted noise. This is what is meant by good presentation.

To satisfy your patrons you must give them

1. Clean and comfortable seats with a clear view of the whole picture from every position.
2. Uninterrupted continuity of showing.
3. Adequate and consistent screen illumination and brightness .
4. Acceptable picture steadiness.
5. Unobtrusive operation of the equipment.
6. Sharp and consistent focus.
7. Good quality of sound reproduction.

After the three hours or more of motion picture entertainment which has been provided, your patrons should be able to leave the theatre with a sense of satisfaction, relaxation and complete enjoyment, unspoilt by feelings of frustration at petty annoyances and minor irritations. So pay regular attention to the following points to ensure a good standard of presentation in your theatre:

House Lights Lighting should be dimmed and extinguished prior to any function of the stage lights and curtains. At the end of the show they should not be raised until all the stage functions have ended.

Stage and Screen Curtains These should be opened at the precise moment a film is projected to provide a well-timed introduction. Their closure should coincide with the last note of the film sound track.

Variable Screen Masking Horizontal and vertical edges must be symmetrical, allowing the minimum overlap of picture to provide a sharp surround.

When changing picture ratio during actual presentation, the variable masking should be operated to ensure a smooth change in picture size.

Projector Changeover The position of the film leader when lacing a projector must be correct for the equipment in use, to provide a perfect and imperceptible change-over, to be followed by an immediate check on light, picture and sound.

Picture Quality The screen should appear evenly illuminated. The projected picture seen from the auditorium must be steady within acceptable limits.

The projected picture must be correctly framed on the screen and definition maintained by careful focus adjustment frequently checked throughout the show.

Sound Quality The auditorium area should be regularly checked during a film performance to ensure quality of reproduction and suitability of volume.

Incidental Music Care should be taken in the choice of records and tapes to ensure that the music played is compatible with the film programme.

LOOK AFTER the copies of films in your care: they are the whole reason why there are paying customers in your theatre.

LOOK AFTER your equipment and make sure that it enables you to keep up a high standard of presentation: the following short trouble-shooting guide can help you to do this.

FAULT-FINDING GUIDE

FAULT	PROBABLE CAUSES	ACTION
Screen Illumination		
Picture too dim (Dark scenes difficult to see)	Incorrect carbon trim	Check lamphouse conditions
	Low voltage or current to lamp	" " "
	Lamphouse mirror out of adjustment	" " "
	Dirty lamphouse mirror	Check and clean
	Dirty lens or port glass	" "
	Discoloured screen	Clean or replace
	Stray light on screen	Find source and shield
Picture too bright (Burnt-out high-lights, continual flicker)	Incorrect carbon trim	Check lamphouse conditions
	High voltage or current to lamp	" " "
	Lamphouse mirror out of adjustment	" " "
Uneven screen brightness (Dark or coloured corners or edges)	Lamphouse mirror out of adjustment	Check lamphouse and adjust
Unsteady brightness (Irregular flicker)	Carbon trim or condition	Check carbon trim regulator
	Fluctuating voltage or current	Check electrical supply
Picture Steadiness		
Vertical unsteadiness (jump or float)	Unlubricated print	Check condition of print
	Perforation damage	" " "
	Insufficient gate tension	Increase gate tension adjustment
	Built-up of dirt on gate pressure pads	Clean carefully
	Intermittent sprocket	Check for worn or hooked teeth and replace if necessary
	Intermittent mechanism	Report if major servicing required
Horizontal unsteadiness (weave)	Lateral guide rolls at gate	Check that spring-loaded guides are free
Focus		
Unsharp on one side only	Gate pressure not even	Adjust gate pads to give equal pressure on each side
Soft overall with flare (halo round bright highlights)	Oil or finger-prints on projection lens	Clean lens with great care, especially the rear surface
Varying in-and-out of focus	Excessive heat buckling film	Check lamphouse conditions and if necessary reduce arc current
Sound		
No sound at all	Amplifier not switched on!	Check operations
	Individual fuse blown	Replace fuse
	Amplifier fault	Report for service check
Loss of high frequency (Lack of clarity and top)	Optical sound-head out of adjustment	Carefully adjust, using test film if possible
	Dirt or oil on optical soundhead lens	Clean very carefully
	Build-up of oxide dust on magnetic heads	Clean very carefully
	Projector components magnetized	Demagnetize sprockets and rollers on film path
	Amplifier fault	Report for service check

FAULT	PROBABLE CAUSES	ACTION
Garbled unintelligible sound	Misthreading of film path to sound head	Check thread-up
	Film loose at scanning point	Check tension roller spring
	Bad contact at magnetic head	Adjust film path for proper tension
"Motor-boating" (Sprocket-hole noise)	Track out of alignment at optical sound-head	Adjust lateral guide roller at sound-head
Irregular Crackling	Corroded contacts or wiring	Clean if possible, report for service check
	Loose connection in photocell or other components	Check and replace if necessary
	Loud-speaker fault	Report for replacement
Hiss and irregular noise on individual print	Scratches and damage in the optical track area	Check condition of print and report for replacement
	Magnetic track has been affected by stray magnetic fields	Report for replacement

Health and Safety at Work

For your own safety and that of your fellow-operators, be sure to follow these simple procedures in your work:

The projection area must be kept clean and tidy, allowing easy access to all parts of the equipment.

The interior of extract flues connected to the projection lamphouses must be kept clear and free from obstructions. Exhaust fans must be maintained in accordance with the supplier's instructions.

Inflammable film (NITRATE) must not be projected, handled or stored on the premises under any circumstances, unless a special licence has been obtained.

Take care when lifting and carrying heavy items, such as transit cases of films, to avoid personal strain and injury.

Only those external adjustments essential for the presentation of a film programme must be carried out while the projection equipment is in operation.

The illumination centre of a carbon or xenon arc must only be viewed through a filter at the aperture provided in the lamphouse for this purpose. Failure to do this may result in injury to the eyes.

The power supply must be switched off when carrying out maintenance to all projection equipment.

The standard safety procedures must be displayed at all times and strictly followed when changing a xenon lamp.

Wherever required, protective clothing and safety equipment such as eye-shields, gloves, etc. must be used correctly. Take care to ensure that equipment and clothing is maintained in safe working order.

When carrying out maintenance on Mercury Arc Rectifiers, the following special instructions must be strictly observed:

a. Switch off power supply.

b. Wear protective shield over the eyes.

c. Handle the mercury bulb with extreme care.

d. Do NOT over-tighten electrode connections.

e. Do NOT touch mercury in the event of bulb damage.

f. Any part of the body coming into direct contact with mercury must be thoroughly cleaned and neutralised immediately.

The Screen

29. SCREEN CARE AND MAINTENANCE

Although often neglected, the screen on which the projected picture finally appears is obviously one of the important factors in motion-picture presentation.

Nothing in the presentation chain should draw attention to the essentially illusory nature of the entertainment and so the screen itself must not intrude. It must have a perfectly homogenous surface, completely free from blemishes and patchiness, its seams must be invisible from the auditorium and it must in no way interfere with the quality of sound reproduced by the loud-speakers placed behind it.

Because of the screen's self-effacement it is often given the least consideration of all the items making up the presentation chain.

If the screen is dirty, yellowed by age, or has blemishes or patches, then the whole concept of good motion-picture presentation is ruined and all the efforts from studio to cinema to provide illusion are ruined.

Screen deterioration through tar contamination

Screens start to deteriorate immediately they are installed because of the smoking that takes place in the auditorium during public performances. This causes a very insidious form of tar contamination on the screen surface and it is inevitable that after a period of service any screen will cease to give satisfactory results.

Importance of regular screen replacement

Regular replacement of screens has everything to commend it except for the cost involved, and it is an absolute necessity in maintaining consistently high standards of motion-picture presentation.

Without the modern metallised screen surfaces, it would be impossible to provide such very large Wide Screen and CinemaScope pictures and still retain good standards of screen brightness and presentation.

Modern high-efficiency screens are not cheap but the wise exhibitor will consider the screen as a semi-consumable item of the greatest importance to the business interests of his cinema, and budget accordingly.

The cost of regular replacement, looked at on the basis of so much per seat per annum against the revenue of that seat is insignificant when one realises that the excellence of motion-picture presentation so greatly depends on the state of the screen.

When to replace the Screen

How does one arrive at knowing when the screen has deteriorated to such an extent as to necessitate replacement? This is a rather difficult problem because economic considerations dictate that the screen is not replaced before this step is absolutely necessary and presentation considerations make it equally necessary that a screen should not remain in use when it is giving indifferent presentation.

The deterioration due to tar contamination is slow and even and it is sometimes very difficult for a person working in a particular cinema to judge just how serious the deterioration is at any period of time. Some simple means of comparison is needed.

Comparison with a piece of white blotting paper is a rough guide but better still a piece of new screen material. Make a test at monthly intervals after the screen has been in use for nine months. When the difference between the deteriorated screen and the test piece is quite marked then picture presentation is being adversely affected. A yellowish tint to the "whites" in a black-and-white film, a lack of sparkle, dull colours, are all signs of screen deterioration beyond a reasonable degree.

The right surface for the shape of the auditorium

Most cinemas to-day either use the modern "silver" screen or the so-called "pearl".

To meet the demands of the larger screens for Wide Screen and CinemaScope presentation the original "silver" screen, which was almost a direct reflector, was modified in that the screen surface reflection characteristics were "controlled" to some extent by various methods. The resultant surface reflected much more light than the older "flat white" and reflected that light into the seating areas instead of all over the walls and ceiling as well.

The so-called "pearl" screen surface was later developed to overcome some deficiencies of the modified "silver" screen. While it is "white" in appearance, something like the older "flat white", it has a semi-specular surface which is controllable in manufacture to give greater light reflection into the seating areas. The complexity of this type of surface makes it almost impossible to re-spray it on site.

The "silver" screen is more suitable for the long narrow auditorium while the "pearl" will cover the shorter wider auditorium.

Care and Maintenance

Once a new screen has been installed in a Cinema auditorium it becomes vulnerable to various factors each of which will in time cause it to deteriorate, giving poor picture presentation and becoming obvious as a screen through damage or blemish.

This Section of the Manual is intended to give some simple rules on the care and maintenance of screen surfaces and hints on the best way of keeping screens in good condition throughout their useful life.

Tar Contamination

The most serious enemy to cinema screens is the tar contamination that results from the smoking that takes place in the auditorium. This is sometimes accentuated by inefficient or wrongly designed ventilation plant.

Under normal conditions this form of deterioration spreads evenly over the uncovered parts of the screen and thereby causes a steady decrease, day by day, in the amount of projection light being reflected back to the audience, thus lowering the standard of picture presentation.

This kind of deterioration also causes a change in the colour of the screen surface which has a bad effect on picture presentation especially when colour films are being shown.

The speed at which this deterioration takes place is determined mainly by local conditions, such as the inherent cleanliness of the locality, the efficiency and location of the ventilation plant, the proper "backing" of the rear surface of the screen, the number of capacities per week, etc.

This tar contamination is very insidious and has defied the continual efforts of the screen manufacturers to find any complete solution. Modern screens are more resistant to tar contamination but the practice of smoking has increased. Such contamination is relatively slow and it is sometimes very difficult for a person working in a particular cinema to know just how much a screen has deteriorated over a period of time.

Screen Tilt

Many screens are tilted slightly from the vertical, generally leaning slightly backwards, in order to provide the best light distribution over circle and stalls. Tilted screens are even more susceptible to staining and dust retention than vertically standing screens.

Staining may also occur through water dropping from a leak in the roof over the stage or through oil or grease that has dropped from a curtain track or from equipment on the grid.

Physical Damage

While the screen material is quite strong and will not easily tear, the great expanse of screen is necessarily susceptible to accidental or deliberate damage and the actual screen surface can easily be marred.

Accidents will happen and work on ladders or even with vacuum cleaners near to the screen is a hazard. Work on speaker assemblies or masking controls behind the screen can also be dangerous and result in a hole or dent in the screen.

There is sometimes deliberate damage caused by missiles, ice cream, etc., thrown or otherwise projected at the screen surface by the audience.

Uneven deterioration

The even deterioration of a screen surface is an unobtrusive menace but uneven deterioration renders the screen immediately useless for it reveals the screen itself and thereby destroys the motion-picture illusion, completely spoiling the presentation.

This uneven deterioration is generally caused by draughts, openings in the screen "backing", by leaving the variable masking closed for a long period of time and other factors.

Before Installation of a New Screen

1. Carefully examine the backstage area.

2. Repair any leakages in the roof – make watertight and weatherproof.

3. Seal all openings likely to cause draughts.

4. Clean stage area to remove dirt and dust from walls, floor and ceiling.

Water must not be allowed to drip on to the screen and backstage draughts will cause air currents to pass through and across the screen area with the possible danger of uneven deterioration.

A rough method of testing for draughts is to project a light on to the screen from a projector or spot arc lamp after closing all auditorium doors and then watch the behaviour of smoke trails from a lighted cigarette. Make several tests when the wind is in different directions.

Check the Plenum plant, if one is installed, to make sure it is operating properly. Backstage exhaust fans can cause rapid screen deterioration.

On Installation of a New Screen

A new screen should be properly "backed" by wool serge or fireproof felt. Where possible the entire screen frame should be totally enclosed at the back, fitting the material closely around the speaker assemblies. This precaution will help to prevent uneven deterioration brought about by the passage of dust and fume-laden air through the screen perforations.

During the life of the screen

At the end of the day's performances always open the top and sides of the variable masking to the full extent. This will present unequal deterioration of the exposed screen surface.

Brush the screen surface periodically with a special screen cleaning brush but always in one direction only – from top to bottom. Undue pressure or a scrubbing motion must be avoided as burnishing may occur which would alter the reflection characteristic of the screen in that area causing patchiness.

Special screen cleaning brushes are obtainable. These do not have any metal projections or allow the wood stock or handle to come into contact with the screen surface. Keep this special brush clean and dry and use it only for screen brushing. Keep the brush covered when not in use – use a polythene bag.

The frequency of brushing depends upon a number of local factors. In some situations this should be once a week while in others once a month is sufficient.

Under conditions of the greatest care it is possible to vacuum clean the screen surface if a clean soft-hair brush tool without projections is used. It cannot be over emphasised that vacuum cleaning a screen should only be undertaken by senior staff as the brush and tubing is unwieldy and damage to the screen surface could easily occur.

Keep the screen frame area and backstage clean and vacuum clean the masking regularly and very carefully.

Screen Lacing

Adjust the screen lacing during the first month of installation of a new screen and thereafter check every six months. Even tension over the whole screen is the aim. Take care that excessive side tension on curved screens does not distort the screen shape in the vertical.

Take care in servicing variable masking

When checking control cables on the variable masking equipment or curtain controls in order to adjust slack cables, make sure that no oil or grease or even dirt falls on the screen surface. Splashes and spot of oil will ruin the screen surface. Never over-oil bobbins and pulleys. It is recommended that grease be used instead of oil.

Emergency action

Should oil, grease or ice cream stains appear on the screen surface immediate action should be taken as follows:

a. Using clean cotton wool or paper tissue moistened with white spirit, the contaminated area should be cleansed taking great care not to spread the patch. It is important that pure white spirit only should be used or the vinyl surface will be disturbed. The spirit must be free from paraffin (some turps substitute is white spirit but frequently has had paraffin added). No other kind of paint solvent should be used.

b. When the grease etc., has been removed the area may be gently washed with toilet soap and water – here again the cotton wool or paper tissue must only be moistened or the affected area will become enlarged. All traces of soap must finally be removed with great care.

c. If the blemish has been caused by dirty water (rain water leaking through the backstage roof) only toilet soap and water need be used. Never use a harsh domestic washing soap.

d. If the screen has been in use for some time before the accident occurs and is therefore already stained with nicotine tar, then an attempt should be made to leave a uniformly stained surface as otherwise the clean patch may well show up more than the dirty patch.

e. The sooner the above steps are taken the greater the chance of success. Keep to the above instructions otherwise the stain may well spread or become worse than if left alone.

Follow all the above instructions, hints and tips carefully to get the maximum useful life out of the screen and thereby enable it to play its important part in better picture presentation.

A great amount of care is shown by the screen manufacturers in providing new screens having no visible seams and without blemish or patchiness of any kind.

30. SCREEN ILLUMINATION AND BRIGHTNESS

The brightness or luminance of the projected image of the film is of fundamental importance and will vary depending on the characteristics of the screen, primarily its reflectivity. British Standard BS 5382:1976 for cinematograph screens describes this factor as reflectance gain, the gain being the ratio of the luminance produced by the projected light falling on a freshly cut surface of magnesium carbonate compared with the luminance from the same light falling on the screen surface. Gain factors greater and less than unity are possible from different types of screen surfaces.

Upper and lower limits of the luminance of the screen/projector combination have been established in many countries. The British Standard BS 5550:7.2.3–1978 was first issued as BS 1404 in 1947 and was revised in 1953 and again in 1961. It was reviewed and confirmed in 1977 and continues to be effective, covering projection of 35 mm on both matt and directional screens.

Photometric Units

The brightness or luminance of a surface depends on the intensity of illumination falling on it together with the reflective properties of the surface in the direction of viewing.

These facts naturally apply to the viewing of a cinema screen. The reflective properties of the screen and the illumination projected on it are the basic factors which determine the picture quality.

With the matt white screen, photometry was relatively simple, but with the introduction of the selectively reflecting metallised screen the problem has become more involved.

There are only three fundamental units of light measurement which are generally applied to the cinema.

1. The Lumen is the unit of quantity of light. It is often used to describe the light output of a projector, the figures quoted giving a guide to the size of screen which can be adequately illuminated. If a certain illumination falls on, say, one square foot of surface it will obviously give a brighter appearance than if it were spread over, say, a square yard. The unit used to describe illumination with respect to the area on which it falls is the foot-candle.

2. The Foot-Candle – is the commonly used unit of incident light and is defined as the level of illumination when one lumen falls on one square foot of surface. Our real interest, however, is the amount of light reflected and this is quoted in foot-lamberts.

3. The Foot-Lambert is the unit used here and in the U.S.A. to describe the brightness or luminance of a surface. It can be defined as the brightness of a perfect reflecting matt white surface when illuminated to an intensity of one foot-candle. This surface would have the same brightness when viewed from any angle and would be reflecting back all the light it receives. The apparent reflectivity of a surface is defined as:

$$\frac{\text{Brightness (Foot-Lamberts)}}{\text{Illumination (Foot-Candles)}}$$

   so that the perfect matt white surface has a constant apparent reflectivity of 1.

   In practice a new matt cinema screen has the apparent reflectivity of the order of 0.8 for most angles of viewing.

   The general formula connecting Reflectivity, Brightness and Illumination is:

$$\underset{\text{(Foot-Lamberts)}}{\text{Brightness or Luminance}} = \underset{\text{(Foot-Candles)}}{\text{Illumination}} \times \text{Apparent Reflectivity}$$

   In these terms, the British Standard for Screen Luminance in 35 mm projection is required to be 12 ft-Lamberts, with limits of 8 and 16 ft-L.

4. In the metric system the preferred term for luminance is candelas per square metre, cd/m^2. For conversion

$$1 \text{ ft-Lambert} = 3.426 \text{ cd/m}^2$$

and

$$1 \text{ cd/m}^2 = 0.2919 \text{ ft-Lamberts}$$

Specular Screen Surfaces

The metallised screens in common use to-day are not uniform in their reflectivity at all angles of viewing and, indeed, behave more like a mirror in that the greatest reflectivity to a ray of light is in the direction of the specular reflection, i.e., where angle of reflection = angle of incidence.

This means that at some angles of viewing the apparent reflectivity can be greater than 1 and the brightness of such a surface at certain viewing angles for the same illumination would be much higher than that of a matt screen which uniformly diffuses the light in all reactions.

It is for this reason that the metallised screen has had general use, as it has enabled the presentation of larger screens to the public at a satisfactory luminance for the same illumination from the projector-arclamp.

Metallised screens can be embossed with extremely small indentations which, in effect, form tiny concave reflectors. By altering the height, width and depth of these indentations a screen can be "tailored" for a particular type of cinema, reflecting the light both horizontally and vertically on to the main body of the audience and not on the walls and ceiling too as with a flat matt screen.

Figures 1 & 2 illustrate the reflective characteristics of various types of metallised screen compared with the matt white screen. The angle away from the centre line (projector to screen) is shown along the bottom of the diagrams and the relative luminance is shown vertically.

Such metallised screens, however, if flat, will give the effect of uneven illumination in a marginal seat. This is shown in Figure 3a where polar diagrams are superimposed on a cinema floor plan. It will be seen that the luminance "a" from the left side of the screen is very much smaller than "b" from the right-hand side. If, however, the screen is curved as in Figure 3b it is obvious that "a" and "b" are equal.

Thus, if a metallised screen is mounted flat, although the illumination on it may be symmetrical, its luminance would only appear symmetrical to a person viewing it from the centre line of the auditorium.

When the screen is suitably curved much of this effect is corrected and although from side seats the screen may still look less bright than from centre seats – the general symmetry of screen brightness is much more tolerable.

As the screen is not curved in the vertical plane this phenomenon still applies if the screen is viewed from bottom to top. Usually the screen appears brighter on the bottom than the top, and although this effect is more noticeable from front stalls seats a similar effect to a lesser degree is sometimes observable from the projection room.

Care should be taken not to try to correct this condition by a vertical mirror tilt of the arclamp or the main body of the audience could well be viewing a screen more out of vertical symmetry than it appears from the projection room.

Screen Tilt

The position of maximum brightness is governed by the rake of the projector and the tilt of the screen.

As the projection rake is fixed, the screen tilt should be adjusted to throw the maximum reflectivity towards the main audience mass and not, as can happen, principally towards the front half of the stalls seats.

Types of Metallised Screens

From Figures 1 and 2 it will be observed that beyond an angle of about 25 degrees the metallised screen has less apparent reflectivity than the matt screen. With the type of screen shown with a high peak value in Fig. 2 the brightness falls off steeply from seats off the centre line and this type of screen is more suitable for the long narrow type of auditorium. A screen surface of the type shown in Fig. 1., having a more modest reflectivity is more suitable for the average shaped auditorium, the fall off in reflectivity not being so prominent when one views the screen from the side seats.

Any position of viewing in the auditorium which subtends an angle greater than 25 degrees with the line of maximum reflectivity will inevitably have a screen brightness lower than that of a new matt screen. Consequently, if a satisfactory screen luminance is to be obtained at these angles the luminance in the direction of maximum reflectivity should be at or near to that of the maximum British Standard of 16 foot-lamberts.

REFLECTANCE CHARACTERISTICS OF HARKNESS CINEMATOGRAPHIC SCREENS

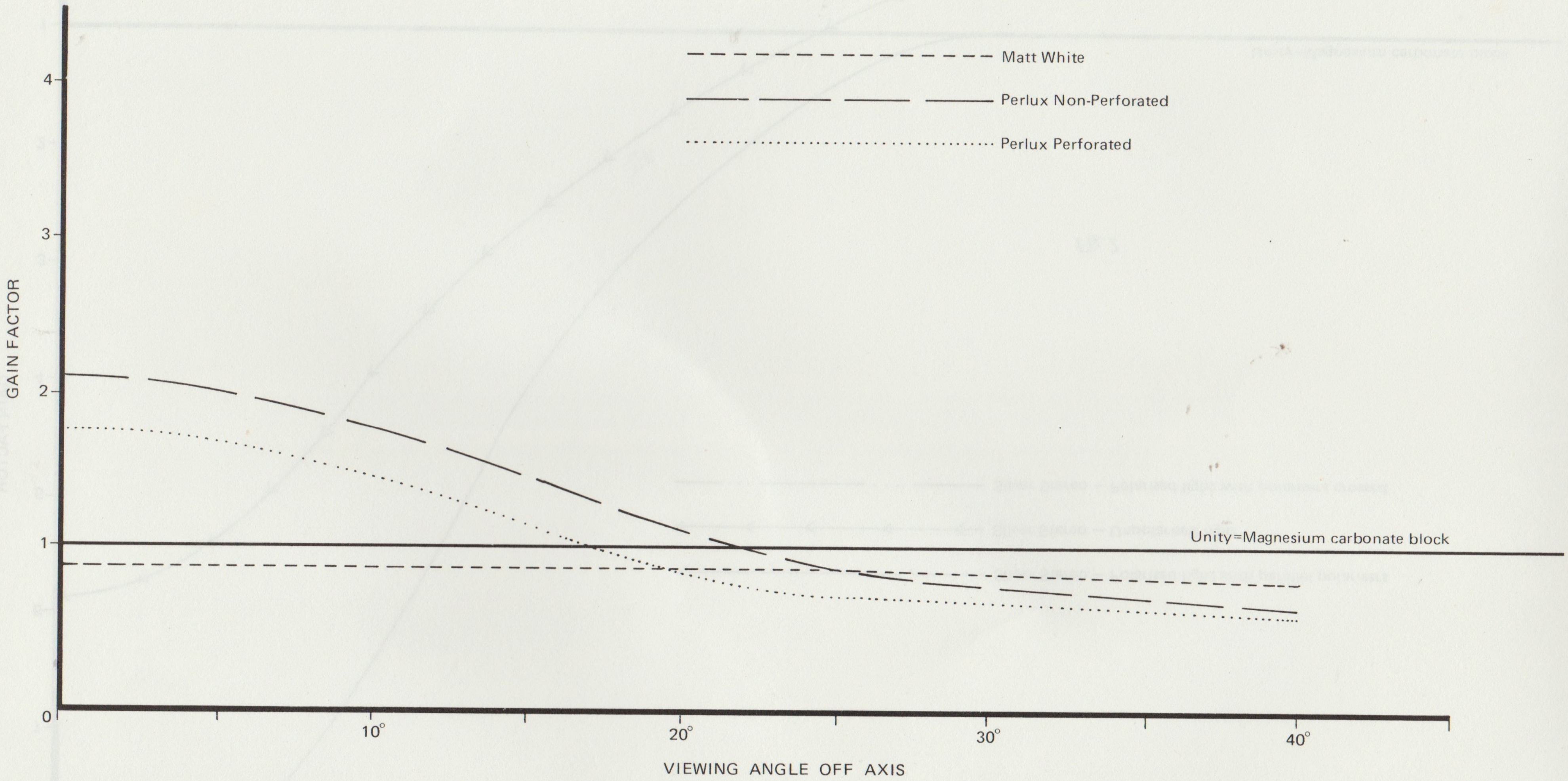


Fig.1

REFLECTANCE CHARACTERISTICS OF HARKNESS SILVER STEREO CINEMATOGRAPHIC SCREENS

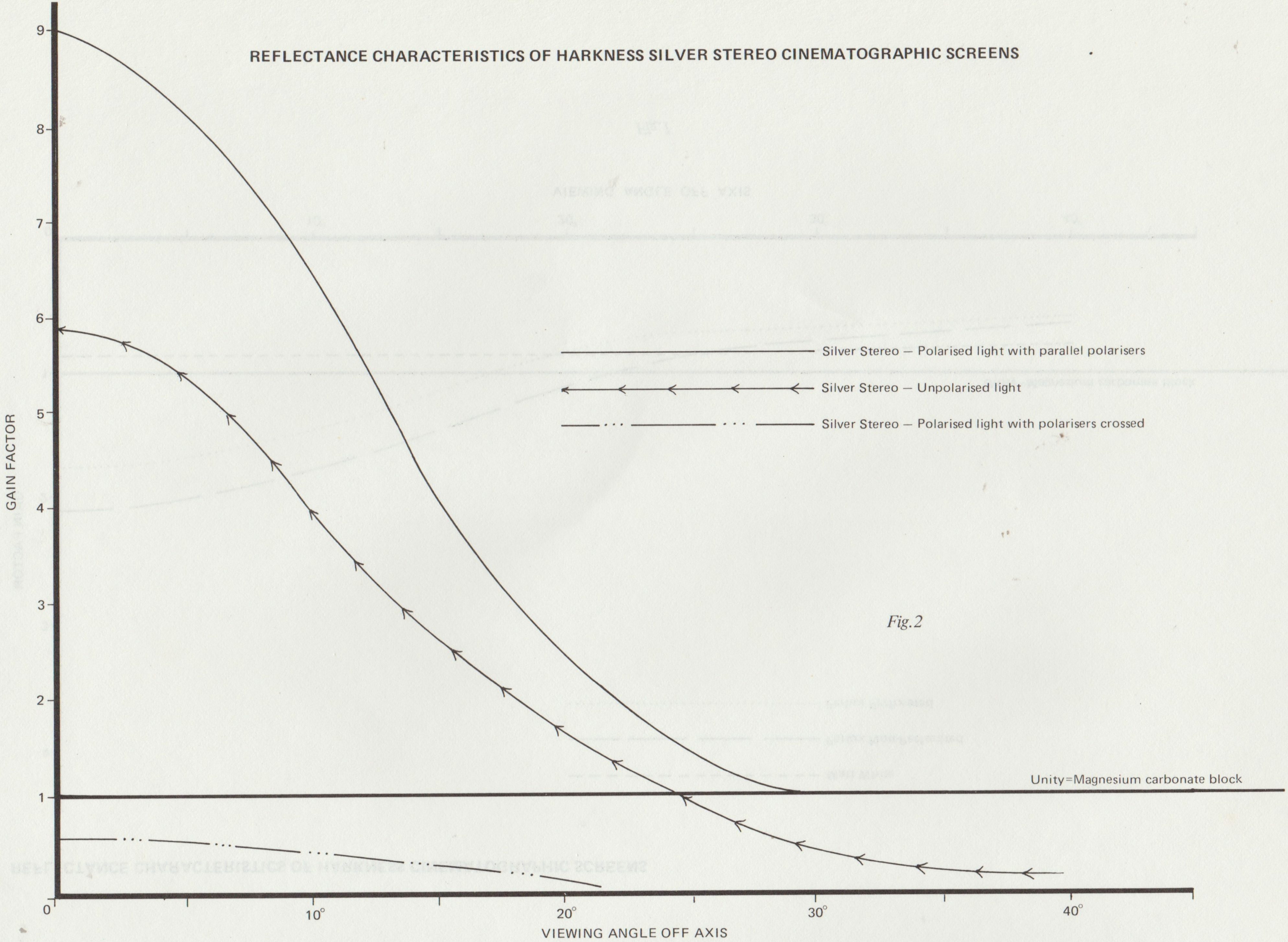


Fig.2

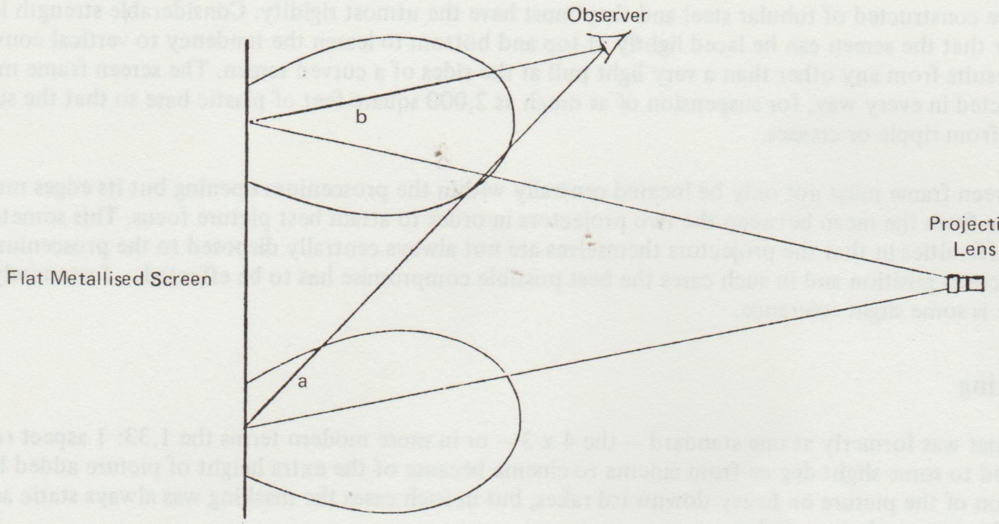

Observer
b
Projection
Lens
Flat Metallised Screen
a

Fig.3a

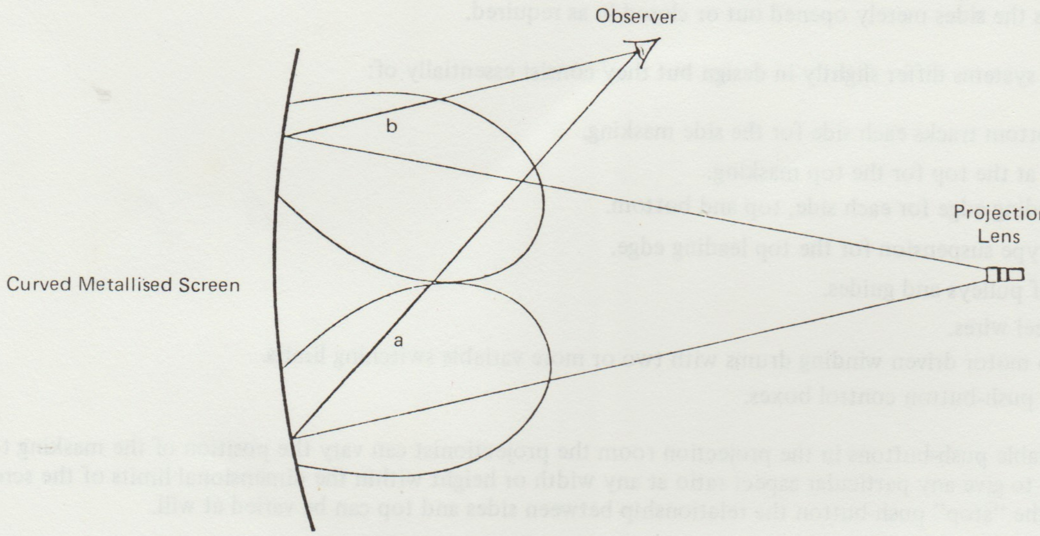

Observer
b
Projection
Lens
Curved Metallised Screen
a

Fig.3b

31. SCREEN FRAMES AND MASKING

The screen frame on which the screen must be mounted and held in optical alignment to the motion-picture projectors, the way in which variable screen curvature and tilt are accommodated and masking altered to suit the aspect ratios and the whole frame made mobile when required is of the greatest importance.

Screen frames are constructed of tubular steel and they must have the utmost rigidity. Considerable strength is also required in order that the screen can be laced lightly at top and bottom to lessen the tendency to vertical convex curvature that results from any other than a very light pull at the sides of a curved screen. The screen frame must be soundly constructed in every way, for suspension of as much as 2,000 square feet of plastic base so that the surface is completely free from ripple or creases.

Naturally the screen frame must not only be located centrally within the proscenium opening but its edges must be the same distance from the mean between the two projectors in order to attain best picture focus. This sometimes presents some difficulties in that the projectors themselves are not always centrally disposed to the proscenium opening or the screen position and in such cases the best possible compromise has to be effected – fortunately in all these cases there is some slight tolerance.

Variable Masking

The picture format was formerly at one standard – the 4 x 3 – or in more modern terms the 1.33: 1 aspect ratio. The format varied to some slight degree from cinema to cinema because of the extra height of picture added by the vertical elongation of the picture on heavy downward rakes, but in such cases the masking was always static and could therefore be given a clean cut edge.

The introduction of CinemaScope and thereafter of various other presentation systems made it necessary to allow for a mounting number of aspect ratios, 1.33: 1, 1.66: 1, 1.75 : 1, 1.85 : 1, 2.0 : 1, 2.35 : 1, 2.55: 1 and so some form of variable masking became necessary.

In this country a static bottom masking line was adopted to be common to all presentation systems and many cinemas also adopted a common picture height or top line where only CinemaScope and Wide Screen presentations were in use. In these cases the sides merely opened out or closed in as required.

Variable masking systems differ slightly in design but they consist essentially of:

a. Top and bottom tracks each side for the side masking.
b. Side tracks at the top for the top masking.
c. A metal leading edge for each side, top and bottom.
d. A festoon type suspension for the top leading edge.
e. A system of pulleys and guides.
f. Flexible steel wires.
g. One or two motor driven winding drums with two or more variable switching limits.
h. Duplicated push-button control boxes.

By operating suitable push-buttons in the projection room the projectionist can vary the position of the masking to limits already set to give any particular aspect ratio at any width or height within the dimensional limits of the screen frame. By using the "stop" push-button the relationship between sides and top can be varied at will.

This equipment operates to match the programme make-up and since mechanical operations are continually involved, and wires are liable to stretch and fray, some service maintenance is required.

The following hints on maintenance will enable the projectionsit to get the best out of his variable masking, avoid breakdown and maintain a clean cut edge to the picture.

First, it is essential to inspect all cables for fraying and wear at least once every three months and all pulleys should be examined to make sure that they run quite freely.

Do not use oil for lubrication – many screens have been ruined by this practice. Lubrication should be carried out by very careful and sparing application of grease to cables, pulleys and tracks.

Troubles that occur when cables have been renewed recently are generally traced to cable stretch, so for at least a period of two months after such work a weekly check should be made and any signs of slackness taken up.

Slackness will also affect the stop positions, so limit switches on the controllers should be adjusted. Proceed as follows:

1. Check rotation of motor.
2. When correct rotation is determined then wind to WIDE by hand.
3. Set the WIDE limit striker (usually the outside one).
4. Check rotation again.
5. Wind by hand to CinemaScope position and set limit striker.
6. Repeat for STANDARD.

Attention to the black masking material is needed regularly especially to the reefed top masking. Although dirt will not necessarily show against the black material, regular vacuum cleaning will keep it clean and assist the masking to function properly.

Screen Curvature

The horizontal barrels on which the actual screen is laced are generally curved in a concave direction with regard to the auditorium. This curvature can vary from 2 ft in 40 ft of width to 10 ft in 50 ft of width or even more. In metric terms, from 0.6 m in 12 m width up to 3 m in 15 m of width.

Although such curvature, especially of the greater depths, is generally a matter of the requirements of the promoter of a particular presentation system to enhance the audience participation through a "wrap-round" effect, the primary reason is to even out the light distribution across the screen in those viewing positions that are at one side of the auditorium. A flat white screen using a diffusive material is quite satisfactory on a flat screen frame but one of the modern specular screen surfaces on a flat screen frame would give the audience seated off centre a brighter picture at the edge nearest to them and then a progressive falling-off in brightness across the screen to the further side. On the other hand, a matt white screen laced on a curved frame has no ill effect.

This curvature, if one can determine a degree of curvature which will suit all the presentation systems to be projected, and this is fortunately possible in most cases, can be built into the outer structure of the screen frame.

The screen frame manufacturers are quite used to making tailor-made screen frames to fit into awkwardly constructed stage spaces and the flexibility of tubular construction lends itself to such special considerations.

Screen frames in which screen curvature can be varied at will, either by motorised control or hand winding, are rather a special and elaborate construction problem, but several are in use in cinemas in this country where Wide Screen presentations, Cinerama, or other specialised road-show presentations are interspersed at times with normal 35 mm. CinemaScope and Wide Screen.

Screen Frame Tilt

In order to compensate somewhat for the heavy downward rakes familiar in many cinemas and to get a level picture brilliancy from stalls and circle seating areas, it is usual to introduce some backward tilt to the screen frame. For practical reasons and considerations of space this tilt is limited to a few degrees. This compromise is arrived at to prevent too much tilt causing trouble with the variable masking gear and excessive collection of dust on the screen surface, especially if the surface is patterned, in order to attain high diffusion.

This screen tilt can be built into the outer screen frame construction so that the frame itself would stand solidly on the floor or it can be obtained by physically tilting the frame backwards and securing it in that position by dead lines from the grid or ceiling of the stage or by supports let into the rear wall.

Screen Frame Mobility

Many cinemas are fitted with a fully equipped stage and in these cases some means to remove the screen frame for stage presentations is necessary.

In other cases there is the need to move the screen frame backwards several feet in order to allow limited space for small stage presentations. In fully equipped cinemas it is sometimes possible to "fly" the whole screen away by lifting it on steel cables with the assistance of counterweighting to the grid. Otherwise the whole frame is generally moved on tracks and wheels to the rear of the stage.

Both these sets of circumstances demand a specially reinforced construction of the screen frame to allow it to be moved without any "whip" or bending and special arrangements to make certain that the screen frame can be repositioned easily and accurately.

Ante-Proscenium Structures

In the desire to give larger pictures it often becomes necessary to erect a structure to carry the large screen which has to be placed within the auditorium directly across the original proscenium arch. Here the screen manufacturers skill comes into its own in the design and manufacture of a complete structure carrying not only the screen and variable masking but also the curtains and their tracks, any pelmets, dress legs and even lighting if this is required, as well as the forestage structure leading up to the picture bottom line. This is specially made to dimensions and shapes to suit the individual architectural features of any particular auditorium.

32. STRAY LIGHT ON THE SCREEN

Degradation of the picture image caused by stray light falling on the screen is often a serious problem. Contrast range can be so reduced that an image with scintillating high-lights and deep shadows becomes a grey uninteresting picture, seen at its worst in classrooms with inadequately curtained windows.

The incidence of stray light on to the screen can be due to several causes, some due to the projection system itself and some to extraneous sources. Some of the causes and remedies are discussed below.

a. Lens flare. If the inner black coating of the lens barrel has deteriorated this can cause serious flare. Remedy – return to manufacturer for repair. The modern coated lens shows reduced flare figures but even here finger marks, dust or oil on the lens surfaces will produce severe flare problems.

b. Dirty port glasses can be another source of stray light. Remove and clean them regularly. They should be of optical glass and used with great care.

c. A projection room painted in very light gloss colours will throw light on to port glasses and observation ports and can cause serious stray light. Subdued colours and well-shaded lights which do not fall on the glasses are the answer.

d. The atmosphere in the auditorium, especially in the U.K. where smoking is permitted, can cause serious stray light problems. The ventilation of the cinema auditorium is extremely important in such circumstances and should work at maximum efficiency.

e. Exit lights and other ambient lighting falling on to the screen should be shaded from the screen itself. Passages opening in to the auditorium can cause intermittent trouble if they are too brightly illuminated.

f. The walls and ceiling of the auditorium itself, if of high reflectance, can be great contributors to stray light falling on the screen but this point has been taken care of in most modern cinemas.

g. The degrading effect of stray light is exaggerated by a screen which has deteriorated and by a lowered screen luminance in an effort to increase picture size beyond the capabilities of the projection apparatus. The use of directional screens can alleviate this problem in some cases.

By attention to all these points in a practical way most of the problems of stray light can be overcome. If any doubts exist on the point, a circuit engineer or service engineer equipped with the necessary spot photometer, black disc and film can carry out a check measurement and ascertain the cause of the problem.

1. The screen luminance is measured **under normal conditions in the auditorium** with open gate in foot-lamberts.

2. A film loop is run which has a density of 1.0 N.D. and a small black disc of 1/20th frame width is placed in the aperture. The luminance of this dark disc on the screen is measured in foot-lamberts.

   $$\text{The percentage of stray light} = \frac{\text{Result of 2}}{\text{Result of 1}} \times 100$$

   If the resultant figure is more than 0.3% the various stray light sources should be eliminated one by one until a satisfactory figure is attained.

Power and Services

33. POWER SUPPLIES AND GENERAL SERVICES – INTRODUCTION

The Chief Projectionist must have an understanding and detailed knowledge of not only the films aspect of his work but also the electrical, safety and, to a lesser extent, the general services associated with his cinema or projection unit.

Although his experience will have built up understanding, the detailed knowledge cannot and must not be committed to memory.

No matter how well the equipment has been installed, and no matter how good is the preventative maintenance, fault conditions will develop.

In order to reduce fault time to a minimum and to facilitate operation and maintenance a framework must be established so that errors and chance is reduced to a minimum.

Whether it is a new installation or one which has been in existence for many years, the framework should be the same and consist of:

1. A log book recording daily any faults which occur and the temporary or permanent repairs made. It should also show any adjustments or modifications made to the equipment and installation together with notes re the ordering of stores and spares.

2. A detailed plan of the electrical distribution circuits showing:

   Cable and wire sizes.

   Circuits lettered and numbered corresponding to lettered distribution switched feed boxes.

   Rating of loads and wattage of bulbs.

   Fuses numbered and their ratings shown including type e.g. rewireable or cartridge. The location of spare fuses should be indicated.

   Bold indication of **isolation** points in case of **FIRE**.

   Indication of isolation points for sections which can be isolated for maintenance together with the location of DANGER panels which are to be hung on switches which have been isolated and fuses removed for maintenance work.

   Four copies of this plan are required:
   - one for the file
   - one for permanent display
   - one for fault finding
   - one for the local FIRE OFFICER.

3. A record book should be maintained covering the annual checks of:

   Insulation values obtained on the circuits
   Earth tests to all units
   Line voltage)
   Phase voltage) All taken under normal load conditions
   Line current)
   Power factor)

4. Should any modifications or additions be required they should be carried out by a competent electrical contractor. On completion they should be inspected and tested in conjunction with the local authority and added to the existing records.

   A revised copy must be sent to the FIRE OFFICER.

5. Two copies of all the manufacturer's manuals or handbooks covering all the equipment must be obtained, (in English if possible).

   The connection details to the equipment should be added to the distribution plan and schedule compiled and displayed with the plan listing the units and phase or line connections with isolator switch and fuse identifications.

6. Recommended electrical and mechanical spares, oils, greases and special test equipment should be obtained. These should be clearly identified, dated and stored in a central position with cool and dry conditions.

7. Plans should be made if possible for the general services with special attention given to water pipes, valves, etc., which may be affected by frost and air conditioning filters which may be blocked by wet fog conditions.

   Any water services required for projector or lamphouse cooling should be taken from the main water distribution system at a point nearest to the intake in order to prevent excessive pressure fluctuations in the cooling system.

   Having established as much of the above framework as possible it will then be possible to form a preventative maintenance plan designed to keep all the equipment distribution and services in a fully operational condition.

General Installation Standards

Any Chief Projectionist or service engineer who wants fuller knowledge of the fundamental requirements of electrical installation and safety should be familiar with the Regulations for the Electrical Equipment of Buildings issued by the Institution of Electrical Engineers and regularly up-dated.

These regulations are extensive but an excellent simplified explanation is the ASEE Illustrated Guide published by the Association of Supervising and Erection Engineers, Wix Hill House, West Horsley, Surrey, which is also regularly revised. Although applicable to all forms of installation, both domestic and industrial, the sections on

Control Distribution and Protection
Conduits and Cables
Installing Apparatus
Materials and Construction

as well as many others are all of practical application to any theatre and will be found most instructive.

34. ELECTRICAL SUPPLIES

The standard medium pressure alternating current supply is either 400 – 415 volts 50 Hz three-phase 4-wire (3 phase + neutral) or 200 – 240 volts 50 Hz single phase 2-wire.

Direct current and two phase supplies are now obsolete but should they occur, special provisions must be made with the supply authority.

Where a three-phase supply is provided, the electrical authority will usually require that the three-phase load of the whole cinema is balanced over the three phases, bearing in mind the varying diversity factors applicable to the cinema operation. The lighting and other single phase circuits must also be balanced about the three phases which means that they must be connected between the NEUTRAL and the phases L1, 2 and 3 in a balanced form.

NOTE: $$\text{LINE-TO-NEUTRAL VOLTS} = \frac{\text{LINE-TO-LINE VOLTS}}{\sqrt{3}}$$

For example, with 415 volts, three-phase, line-to-neutral is

$$\frac{415}{1.732} = 240 \text{ volts}$$

For tariff purposes, consumers are divided into four broad classes: domestic, farm, commercial and industrial. There are generally two types of tariff available as alternatives to consumers in the 'commercial' class which include cinemas.

They are:

a. Measured maximum demand tariffs with a demand charge in KVA and a low unit charge.

b. Tariffs with an assessed initial charge followed by a low unit charge but not generally so low as in a. These are generally for the smaller consumer where the expense of maximum demand metering is not warranted.

Penalties exist in some tariffs such as a. for low power factor.

$$\text{POWER FACTOR} = \frac{\text{Mean power}}{\text{Apparent power}} = \frac{\text{true watts}}{\text{volt amps}} \text{ or } \frac{\text{KW}}{\text{KVA}}$$

i.e. KVA x PF = KW

Loads with a power factor below unity involve the suppliers in increased cost for generation and distribution and therefore consumers are penalised by additional charges.

Should the consumer's load have a low power factor the amount of correction should be carefully assessed to give the lowest overall cost to the consumer.

Correction is best obtained by adding capacity to individual inductive loads but, as the effect of adding capacity is greatest when the power factor is lowest, it is not commercially advisable to attempt to raise it much above 0.9.

Joint discussions should be held with the District Commercial Engineer from the local district office of the Regional Electricity Board. These would establish that the correct tariff is chosen for the supply of electrical power and lighting and whether it is economical to apply a degree of power factor correction.

It must be remembered that both the consumer's demand and utilization affect the supplier's tariff charges. The tariffs should be reviewed every one or two years and changes made if necessary.

35. LIGHTING

Lighting may be divided into four categories:

1. External lighting.
2. Decorative lighting.
3. Primary maintained and management lighting.
4. Secondary maintained or safety lighting.

External Lighting

1. The canopy lighting and signs are most important as the exterior appearance is the first thing to be presented to the patrons.

Decorative Lighting

2. This will include the main auditorium lighting, stage lighting and any spot or flood lighting, for curtains or proscenium. Under certain conditions this load could be large and may have to be restricted at certain times due to supply tariff limitations.

Primary Maintained and Management Lighting

3. All areas where it is necessary to maintain permanent illumination during the time that the cinema is open to the public will be fed from this source. Exit boxes and directional signs and lighting points in the auditorium, toilets, foyers, exit passages, offices etc, are dealt with here. The load is small and constant.

Secondary Maintained or Safety Lighting

4. The secondary maintained or safety lighting is covered by the British Standard Code of Practice CP 1007:1955, B.S.S. 764:1954, the Cinematograph (Safety) Regulations, 1955, Statutory Instrument 1955 No 1129, G.L.C. and other area Authority Regulations.

It will be found that the lighting serving specific purposes is required to be derived from a source other than that which supplies the general lighting of the premises except in so far as the provision of a system using a change-over switch in conjunction with a trickle-charged battery supply, or a floating battery system, is permitted.

Maintained Operation (Trickle-charged battery)

In this system the supply is normally provided by a step-down transformer/rectifier which is connected to the load by a continuously energised change-over contactor. In the event of a mains failure, this contactor will drop out and connect the battery to feed the lamp load. This system enables the most suitable lamp supply voltage to be used under normal operating conditions for an effective compromise between light output and lamp life.

The batteries are trickle-charged on a constant voltage method which also has a constant current characteristic to prevent overloading in the event of a battery short circuit together with a boost voltage facility to enable commissioning and occasional freshening charges to be given.

Floating Systems

For this method of operation, the output of the charger is designed to supply the load at the float voltage of the battery which is permanently connected. In order to prevent over- or under-volting the charger must have automatic control to give a present output regardless of load conditions.

This system suffers from the fact that the floating voltage of any battery is considerably higher than that at which it can provide power output, consequently, in this system during mains healthy conditions, the lamps are brightly illuminated but in a mains failure condition the lights level reduces significantly.

It is a general regulation that all secondary lighting should be switched on and checked prior to the public being admitted.

All batteries should be in a fully charged condition every day and be capable of carrying their full lighting load for at least three hours.

No lamps should be added and no increase should be made in the lamp wattages on the safety lighting circuit unless it is certain that the battery has a sufficient capacity to carry the increased load for the full period of time demanded by the Statutory Regulations.

Since the voltage of the safety lighting may vary between 12 volts and 240 volts, it is highly desirable that the lamp holders connected to the safety lighting points be of a type other than those in use on the main lighting installation.

Mains Faults and Failures

Much time can often be saved if mains and supply failures are correctly reported. The following information may be of help in minimising the delay in restarting power.

The projectionist should know:

1. The correct telephone number to ring for day and night faults. This number is not necessarily that of the local District Office.

2. The number and position of the points of supply to the cinema.

The Electricity Board will wish to know the extent of the failure thus:

a. Partial or complete on one or more phases at one point of supply.
b. A complete point of supply.
c. All points of supply (if more than one).
d. If possible, neighbouring buildings, including street lights and traffic signals.

The projectionist must not attempt to examine the Electricity Board's main fuses; he should isolate the Projection Room before leaving it.

36. RECTIFIERS

The function of the power supply is to provide:

a. Transformation of the incoming AC voltage in order to obtain the desired operating voltage.
b. Rectification
c. Filtering.
d. Ballasting/regulation.
e. Stability.

These four functions are adequate to supply the DC current requirements for high intensity carbon mirror arc lamps.

However, to operate a Xenon arc lamp satisfactorily, extra critical functions are required; including

f. Sufficient open circuit voltage.
g. Fast starting current rise time.
h. Peak inrush current limiting.
j. Control of starting transient duration.
k. Compensation for lamp tolerance.
l. Compensation for lamp tolerance.
m. Output adjustability without affecting other parameters.
n. Auxiliary supplies to the lamp ignition unit, cooling fans, remote control etc.

Rectification is common to all units and depending upon the age of the installation one of the following types of rectifier will have been incorporated:

a. Mercury arc or cold cathode.
b. Thermionic or hot cathode.
c. Metal (Dry plate and semiconductors).

These rectifiers may be further subdivided:

i. Copper oxide.
ii. Selenium.
iii. Germanium.
iv. Silicon.

All the above units are capable of producing a form of direct current from an applied alternating current by utilizing the same principle,

i.e. The forward resistance is low and the reverse resistance is high.

If the applied voltage is in such a direction that the current flows as follows:

a. From the carbon anode to the mercury pool.
b. From the anode to the hot cathode.
c. i. From the copper oxide to the copper.
c. ii. From the selenium to a tin cadmium alloy layer.
c. iii. From the p-type semiconductor across the junction to the n-type semi-conductor.
c. iv. From the p-type semiconductor across the junction to the n-type semi-conductor.

then in the forward direction the conductivity is many times greater than when the current tendency is to flow in the reverse direction.

This gives what is known as half-wave rectification and, when subjected to an alternating voltage, current flows during one half of the cycle only. Groups a, b, c.i. and c.ii. are now obsolete and most power rectifiers utilise the Germanium or Silicon units.

Germanium and Silicon junction diodes are both manufactured by making a very pure single crystal of the element, the impurities being limited to the order of one or two parts per 10^{10} and each of the elements have a valency of 4.

Impurities are then added in controlled amounts, known as doping, to the pure crystal to form either a p or an n material; (n for negative carrier and p for positive carrier).

a. To form p material: indium, boron or aluminium (known as acceptors with a valency of 3).

b. To form n material: Arsenic, Antimony or phosphorous (known as donors with a valency of 5).

A pn junction is a transition from p type to n type material. The transition must occur in a continuous single crystal lattice so that the junction must be produced by one of the two basic processes – alloying or diffusion to a controlled thickness. It is impossible to obtain a pn junction by making separate p-type and n-type pieces of semiconductor and bringing them together into contact.

Silicon junction diodes have very high reverse voltages and since they can operate at higher temperatures than germanium junctions they are the main type now used for power rectifiers.

Silicon power rectifiers are marked with polarities and the screw stud type are usually made with the stud as cathode. Great care must be taken to fit in the correct polarity.

With stud or flange mounted power diodes it is important to ensure that they are mounted tightly on the heat sink but care must be taken to avoid the application of excessive force, otherwise mechanical damage may result. In this connection, it is especially important to ensure strict compliance with the manufacturer's recommendations, as the overall power rating of the unit plus its heat sink will depend on the assembly.

The manufacturer's specification usually shows the maximum allowable torque for good thermal contact.

The manufacturer's recommendations must be followed also on the soldering methods to be used on the wire and tag connected units.

The resultant current is unidirectional (except for a very small current indeed during the reverse half of the wave).

This intermittent nature of the current is undesirable as it is in the form of a ripple i.e. it rises from zero to a maximum, back to zero, pause at zero and repeating.

This intermittent effect can be largely overcome by employing full wave rectification and further by applying a three phase instead of a single phase voltage.

The six principle circuits employed for rectification together with the theoretical ripples in % of the fundamental AC supply are shown on the following page.

From these it will be seen that the rectified current obtained by these methods flucuates in magnitude at a rhythmical rate depending on the frequency and method of rectification.

Before applying the rectified supply to the arc it is necessary to smooth it further, the simplest way being to insert a choking coil or inductance, in series with the DC line.

NOTE The unsmoothed output from a rectifier can be looked upon as two current components

i. A steady DC.
ii. An AC current superimposed upon it.

It is this latter AC component of the output current which causes the pulsations and it is this component which is reduced by the insertion of the inductance in the circuit. The constant DC component is unaffected by the presence of the inductance.

A further improvement in the smoothing is obtained by adding two large capacitors in parallel with the DC load one each side of the inductance.

The action of the condenser is to form a reservoir which will either give or take current, thus tending to keep the potential smooth.

As previously mentioned, the two types of rectifiers currently used in power supply units for projection arcs are germanium and silicon with remaining types completely outdated.

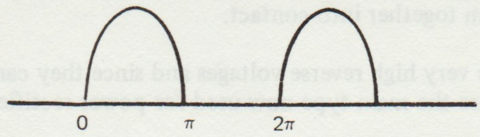
The units of the germanium and silicon rectifier are built up in series for voltage characteristic and parallel for current and assembled on heat sinks to form the specific type of rectifier connection.

For the larger sizes of arc and most Xenon application the silicon unit is chosen, as for a given duty they are smaller, will withstand higher temperatures on load and are hermetically sealed and hence do not age.

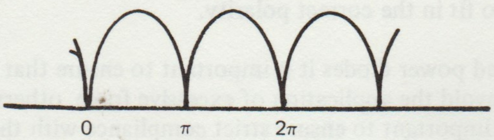
As a carbon arc will tolerate a greater current ripple it is adequate to use a single phase full wave rectifier together with smoothing. A Xenon arc, however, must be supplied with a current ripple of less than 10% peak-to-peak and on critical applications requiring very steady light may call for as little as 0.1% current ripple. Therefore, wherever possible the Xenon lamp should be supplied from a three phase full wave rectifier and smoothed as required. The average Xenon power supply is designed for a maximum peak-to-peak ripple of 7 to 8%.

ripple

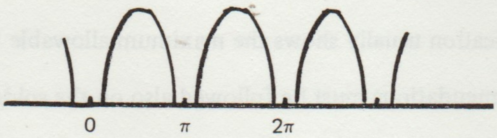
a. single phase half wave — 121%



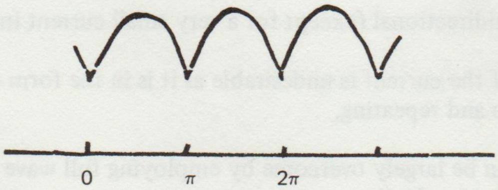
b. single phase full wave bridge — 48.3%



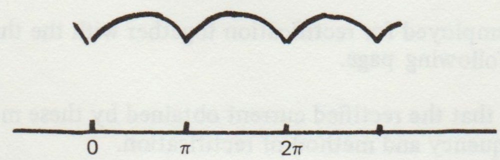
c. single phase full wave (centre tap) — 48.3%



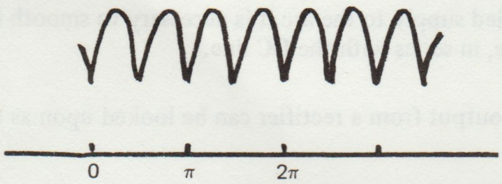
d. three phase half wave — 18.3%



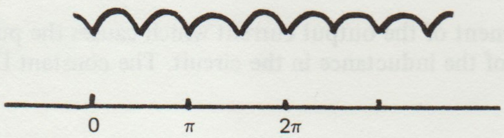
capacitive load



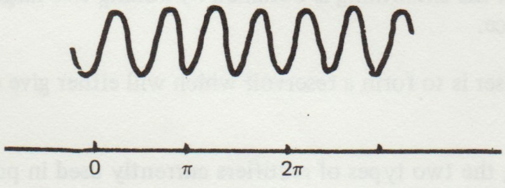
e. three phase bridge — 4.2%



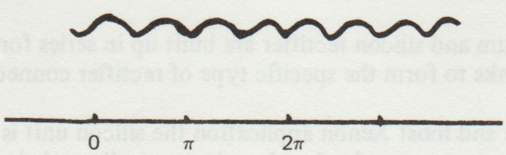
capacitive load



f. three phase centre tap — 4.2%



capacitive load



NOTE Special attention must be given to the silicon units when used in conjunction with a Xenon lamp. The reason is that the RF energy conducted and/or radiated by the igniter during the starting cycle often produces large voltage spikes. These spikes appear as non-repetitive peak reverse voltages and must be damped by bridging each rectifier unit (6 in the case of a three phase full wave) by a high voltage condenser (example 0.22μ F, 1000 volt working).

The ballasting suitable for the carbon arc is described in the section on the Theory of Carbon Arcs but for the Xenon lamp it can be in the form of a separate reactor but it is usually preferable to combine it with the input step-down isolation transformer, making it a high and variable transformer. The control of the adjustable magnetic shunt, brought to a hand wheel on the front panel of the unit, enables the output to be adjusted without affecting other parameters.

In order to heat the cathode sufficiently to start the electron flow, the power supply must also provide an initial 'open circuit' voltage of about three times the operating voltage. A voltage of up to 4 times the operating voltage is often preferred for higher starting reliability.

Since the size of the input transformer is determined by the product of the maximum voltage and the maximum current, even if these do not occur simultaneously, this would result in a transformer larger than needed 90% of the time. Therefore, it is more practical to separate the starting and running voltages. However, to allow the starting – or boost – voltage to be rated only for charging a capacitor, (example 3400μF, 100 volt working) it must be decoupled once the lamp is on. This can be done by an active element, such as a relay or transistor, by impedance, such as a resistor reactor, or by a separate high impedance transformer.

Schematic showing a single phase (for simplicity) bridge-connected rectifier with boost transformer, fig 1.

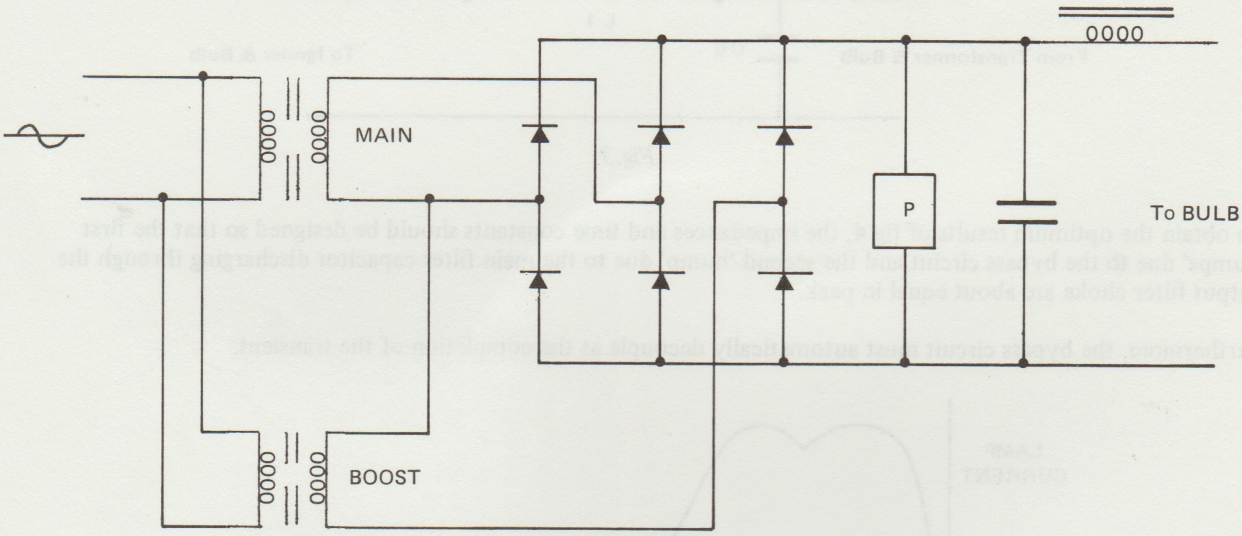


Fig.1

This schematic shows:

i. Step down transformer with ballast (high impedance transformer).

ii. Rectifiers with protectors P.

iii. Filter.

iv. High impedance boost circuit.

The circuit is not yet complete because this form will not result in reliable starts. The current rise time is too slow, due to the output choke. On the other hand, accelerating the rise time by placing a sufficiently large capacitor in the output would cause the in-rush current to damage the lamp. Furthermore, ignition may still be unreliable due to the ensuing transient undershoot and operation may become unstable.

Therefore the additional components in fig 2 or 3 are used to:

i. Limit the rise time to say 1 millisecond.

ii. Limit the current over-shoot to 3 times rated.

iii. Produce a minimum in-rush current of 2 times rated.

iv. Critically damp the current transient. (No undershoot).

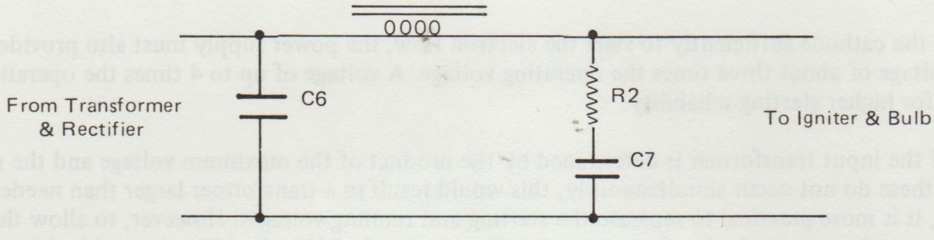


Fig.2

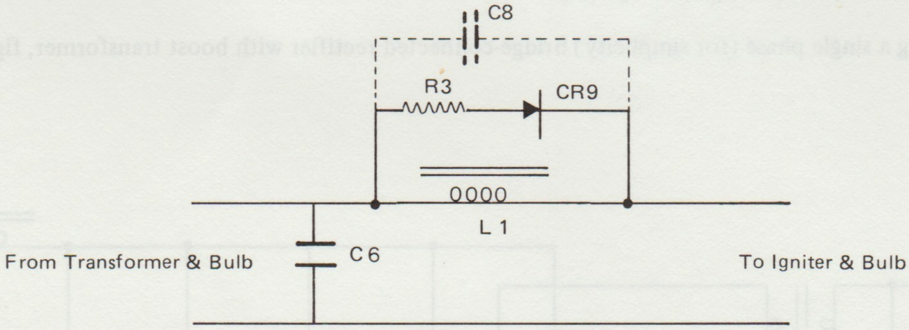


Fig.3

To obtain the optimum results of fig 4, the impedances and time constants should be designed so that the first 'humps' due to the bypass circiut and the second 'hump' due to the main filter capacitor discharging through the output filter choke are about equal in peak.

Furthermore, the bypass circuit must automatically decouple at the completion of the transient.

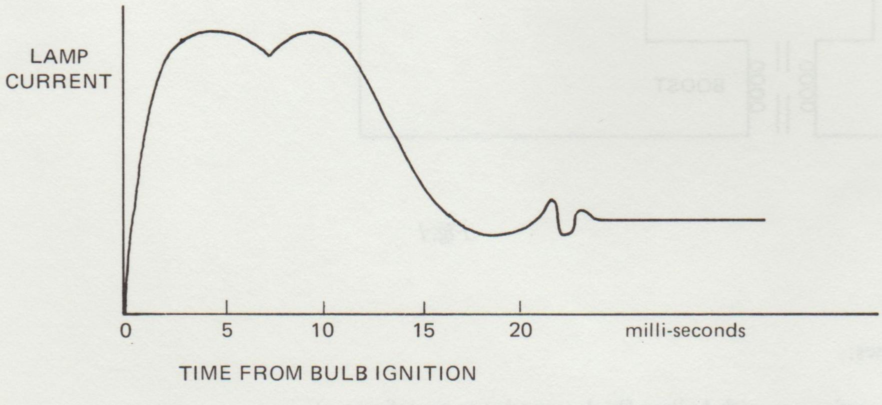


Fig.4

In the foregoing figures, Fig. 2 shows the common capacitor start circuit and Fig. 3 an improved patented circuit (Patent assigned to Christie Electric).

The components are selected for the bypass circuit to attain the correct characteristic for the first 'hump'. These are the capacitor C7 and resistor R2 in Fig. 2 and diode CR9 and resistor R3 in Fig. 3. The optional capacitor C8 can be used to help shape the time constant of the starting current.

The characteristic for the second 'hump' is obtained by the magnitude of the capacitor C6 in both circuits.

37. GENERAL MAINTENANCE OF THE ELECTRICAL EQUIPMENT

In order to obtain good quality picture and sound presentation it is necessary to apply preventative maintenance to the equipment.

The earthing of all the equipment must be checked and maintained in good condition. There are two main classes of earthing:

a. Earthing of equipment for safety reasons.

b. Earthing of equipment and the screening of leads to prevent the 'pick up' of noise or interference.

Any defects in the safety earthing circuits can cause interference which will appear as noise in the sound systems.

Mains borne noise in the form of voltage spikes, together with those produced by the motors, switches, xenon lamp ignition devices, etc., will all affect the sound quality unless the earthing and the screening of leads is maintained in perfect condition.

In order to make the earthing of sound equipment successful it must be separated from the normal equipment safety earths. The ohmic resistance to earth should be as low as possible and, if multiple earth connections are required in the system, they must be made in such a way that potential drops on earth leads which are produced by noise current flowing in these leads are not transmitted to other units in the form of noise voltages.

In order to achieve the best possible protection from noise voltages in sound systems, the following points must be observed:

1. Given the correct audio-frequency zero lead connection between several amplifiers, the whole system should be connected to the earth lead at a single point. (Fig. 1)

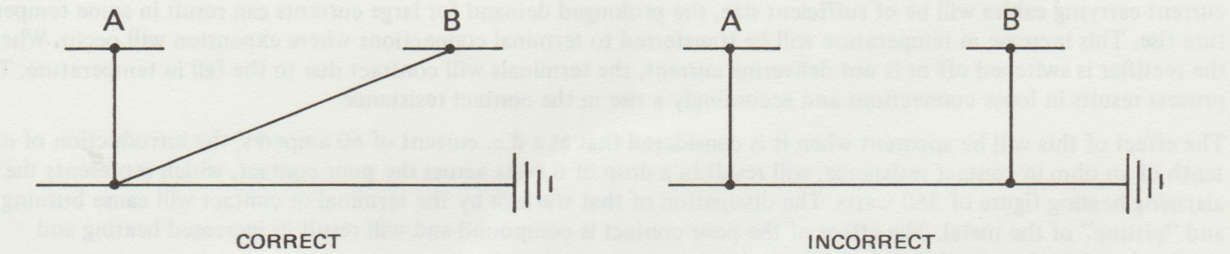


Fig.1

2. If separate earthing of several components of a sound system is necessary for operational reasons, then the various earth connections required should be taken to a single point of the earth lead in star configuration. (Fig. 2)

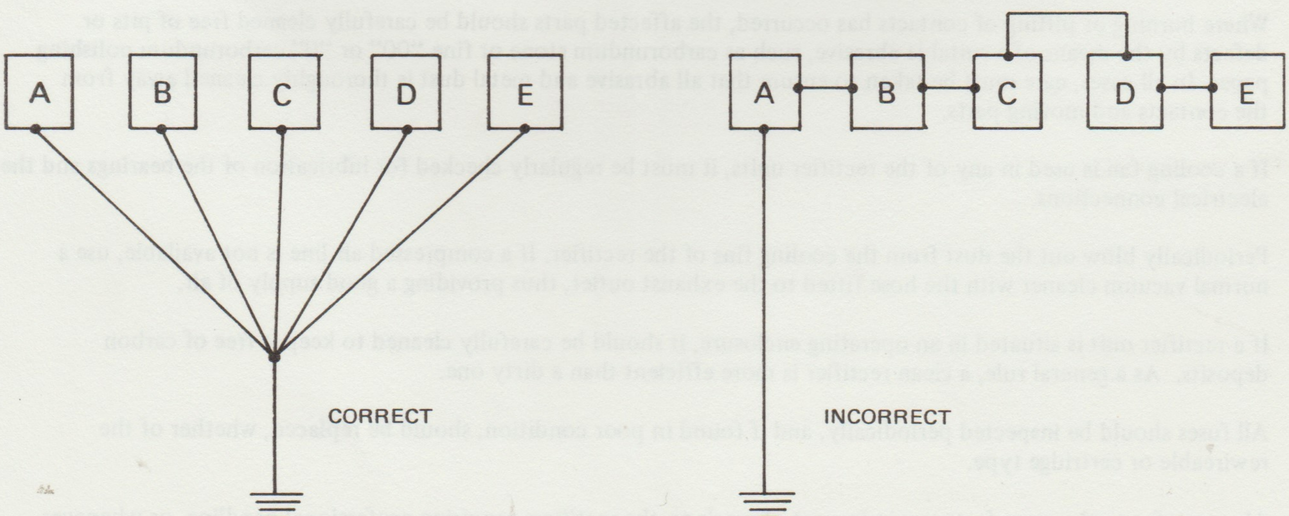


Fig.2

Before checking the power and sound equipment it must be emphasised that no attempt should be made to carry out work on any unit unless it is isolated from the mains, preferably with the main fuses for the circuit in possession of the person carrying out the work, and a card or tag should be attached to the isolator, stating

"WORKING ON EQUIPMENT"

As a final recommendation regarding certain factors that are common to all cinema projector arc rectifiers, it is the heat that is generated which makes adequate ventilation essential if one is to maintain the installation in first-class operational efficiency.

Some rectifier units are fitted with a cooling fan to assist in the circulation of air around the rectifier assembly. Most modern units have a maximum temperature figure quoted and it is vital that this temperature must not be exceeded.

The ventilation of rectifiers is extremely important and therefore one must select a location which provides good ventilation and freedom from dust, particularly abrasive dust. These deposits tend to collect between the cooling fins of rectifiers, electrical contacts and switchgear – this can prove harmful and eventually cause breakdown.

Rectifier units may differ quite widely in certain physical respects, but are often remarkably similar so far as electrical connections and switching are concerned.

All circuits on alternating current (a.c.) supplies are subjected to physical stresses which are caused by vibration set up at the frequency of the mains supply, normally 50 Hz in Europe. Over a period of time these vibrations can cause terminal screws and nuts to work loose on the screw threads.

Terminal screws and studs on fuse carriers, fuse holders, relays, contactors and all the electrical connections associated with rectifier units should be inspected periodically to check if any connections are loose or bad contacts have occurred, thus setting up a high resistance path. If terminals require tightening, use the correct size, well-fitting screwdriver or spanner; do not apply undue force when tightening the terminals and if such force is necessary, ascertain the cause and apply the remedy that appears correct before further damage or deterioration can occur.

Whilst on the subject of electrical connections it must be borne in mind that in d.c. circuits, currents are frequently of the order of 55 – 65 amperes and in some of the larger cinemas these figures are considerably greater. Although the current carrying cables will be of sufficient size, the prolonged demand for large currents can result in some temperature rise. This increase in temperature will be transferred to terminal connections where expansion will occur. When the rectifier is switched off or is not delivering current, the terminals will contract due to the fall in temperature. This process results in loose connections and accordingly a rise in the contact resistance.

The effect of this will be apparent when it is considered that at a d.c. current of 60 amperes, the introduction of one tenth of an ohm in contact resistance, will result in a drop of 6 volts across the poor contact, which represents the alarming heating figure of 360 watts. The dissipation of that wattage by the terminal or contact will cause burning and "pitting" of the metal. The effect of the poor contact is compound and will result in increased heating and greater deterioration, until final breakdown occurs.

There are other causes of increases in contact resistance:–

a. Oxidation of metal surfaces such as switch blades, relay or contactor contacts, both moving and fixed.

b. Loss of contact pressure due to the degeneration of springs or the metal fatigue of the switch or relay contacts.

To remedy such defects, one must either reset the contacts and springs or replace the defective parts. This work, if carried out by the projectionist, must be done with great care.

Where burning or pitting of contacts has occurred, the affected parts should be carefully cleaned free of pits or defects by the means of a suitable abrasive, such as carborundum stone or fine "00" or "0" carborundum polishing paper. In all cases, care must be taken to ensure that all abrasive and metal dust is thoroughly cleaned away from the contacts and moving parts.

If a cooling fan is used in any of the rectifier units, it must be regularly checked for lubrication of the bearings and the electrical connections.

Periodically blow out the dust from the cooling fins of the rectifier. If a compressed air line is not available, use a normal vacuum cleaner with the hose fitted to the exhaust outlet, thus providing a good supply of air.

If a rectifier unit is situated in an operating enclosure, it should be carefully cleaned to keep it free of carbon deposits. As a general rule, a clean rectifier is more efficient than a dirty one.

All fuses should be inspected periodically, and if found in poor condition, should be replaced, whether of the rewireable or cartridge type.

Always refer to the manufacturers in respect of work on the rectifiers requiring professional handling, or whenever information is required about the equipment.

38. THE VENTILATION OF MODERN CINEMAS

The provision of comfort conditions for theatre patrons is a most important aspect of theatre management. Comfort is a combination of many factors foremost of which are adequate heating, good ventilation and where available air conditioning.

The application of heating, ventilating and air conditioning techniques to theatres is a highly specialised branch of mechanical services engineering but the basic principles can be readily understood by the layman thus enabling him to derive maximum effectiveness from the available plant.

Ventilation

Ventilation is the introduction of fresh air and the removal of vitiated air and has three main functions:

a. To provide a continuous supply of oxygen for breathing.
b. To remove products of respiration and occupation.
c. To remove "artificial" contaminants such as smoke.

Air Conditioning

Ventilation alone cannot adequately control the temperature and relative humidity within the theatre. In Summer especially the temperature within the theatre, with full occupancy, is likely to rise above the outside ambient if air conditioning is not available. Fairly close control of the relative humidity also adds greatly to the feeling of comfort.

Heating

The basic requirements of the heating system are obvious. The system may serve radiators or convectors in the auditorium and other areas or heater batteries in the ventilation supply air system or more probably a combination of the two. Minimum temperatures are usually quoted as 15^{O}C but a more usual level would be 18^{O}C.

Methods of Ventilation

Mechanical Extract Only

In some old theatres the ventilation may be by mechanical extract only. In this type of system the air is removed at high level by extract fans and the supply or make-up air is drawn into the auditorium from outside via cracks beneath doors, windows or purpose made inlet grilles. The heating is achieved solely from radiators or convectors. Even if the openings to outside are positioned behind the heaters it is almost impossible to achieve draught free conditions in Winter. Usually the inlets tend to get sealed up but this of course will reduce the ventilation rate to an unacceptable level.

Plenum System of Heating and Ventilation

These systems consist of mechanical supply ventilation as well as mechanical extract.

The system is arranged so that the incoming air can be heated to a temperature sufficiently above the space temperature to offset the fabric heat losses, there being no auxiliary heating system in the space. (An alternative system heats the incoming air to space temperature only, the fabric losses being made up by auxiliary means such as radiators or convectors).

Under G.L.C., and other regulations the minimum amount of input air supplied to an auditorium must be no less than 8 litre/s per person. Ventilation may also be required to foyers, waiting spaces or other portions of the premises occupied by the public, performers or staff. A minimum temperature of 13^{O}C must be maintained with full air supply when the external temperature is 0^{O}C.

The air admitted must be suitably cleaned and warmed so as to maintain equable conditions at all times. When no other treatment is provided (i.e., no air conditioning equipment) not less than 6 litre/s per person of the admitted air shall be fresh air taken from outside the premises. (Some designers use a figure of 8 litre/s per person for the fresh air requirement). The remainder of the air may be recirculated from within the premises.

Where equipment is provided for the complete conditioning of the air and is capable of maintaining, without regard to external weather conditions, the relative humidity of the occupied space at no more than 55 per cent, then the amount of fresh air may be reduced to no less than 4 litre/s per person.

Designers generally use figures in excess of the foregoing and air change rates of 6-10 changes per hour are common. It is usual to supply more air to the space than is extracted thus maintaining a slight pressure within the auditorium. This will produce an outward air movement through doors and other openings which prevents the ingress of dirt and untreated air.

Any mechanical air input system serving a stage provided with a safety curtain must be entirely independent of the auditorium input system as must any ventilation systems provided for kitchens, toilets and similar areas.

Supply air is drawn from outside (a proportion of recirculated air is also generally added to the supply air) by a fan and made to pass through a filter (or washer), heater battery and cooler battery where air conditioning is provided. The treated air is then delivered into the auditorium by means of fire resisting trunking. The materials used for the ventilation and heating equipment should be non-combustible as far as practical.

The extract system draws air from the auditorium recirculating a proportion of it and the rest being exhausted to atmosphere. The exhausted air does not generally exceed 75 per cent of the quantity of fresh air admitted.

There are many different types of distribution systems used in theatres. The architectural treatment and theatre structure will effect the positions in which air can be introduced and removed. In small theatres single supply and extract positions are often used but in large theatres air is supplied both at high (ceiling) level and under the balcony with the extracts often mushroom shaped grilles under the seats.

The balancing of a ventilation system is a complicated process and should only be undertaken by specialists. The dampers provided for balancing either in the ductwork or incorporated in the grilles should not be interfered with. The closing, or opening, of a few dampers can ruin hours of work and if the balance is disturbed complaints of draughts are likely to occur.

These days control of the ventilation and heating is unlikely to be a problem as efficient automatic thermostatic controls are likely to be fitted. They must be intelligently adjusted, however, so that they can carry out their intended function. The correct settings for thermostats has often to be obtained empirically to achieve the greatest possible degree of comfort in the auditorium. Time clocks should be adjusted to switch plans on and off in accordance with the proposed weekly or daily programme.

During the winter the supply air temperature at the grilles will be higher than the auditorium temperature. As a general guide with an auditorium temperature of 18°C the supply air temperature might be of the order of 27°C or even higher. In Summer, if air conditioning plant is available, the supply air temperature would probably be about 10°C lower than the auditorium temperature depending on the type of air distribution.

Allowance should also be made for the heat emission of the human body. An adult male seated at rest emits approximately 115 W (i.e. an audience of 200 persons would be producing 23 KW). It can therefore be seen that in Summer the inside temperature of the auditorium must of necessity be rather higher than the outside shade temperature unless cooling equipment (air conditioning) is available.

Systems vary greatly and it is therefore impossible to give detailed maintenance and operation instructions. There are, however, general points that apply to all plant and these are listed below.

1. As with any mechanical plant cleanliness is most important. A dirty heater battery will not only give off less heat but the added resistance will reduce the supply air volume thus unbalancing the system.

2. Filters must be cleaned or changed regularly. The state of a filter can often be ascertained by visual inspection but on many plants a gauge is fitted which indicates the increase of resistance (dirtiness) of the filter. When a predetermined level is reached the filter should be cleaned or changed. Washable filters must be treated in the way specified by the manufacturers or else they may lose their filtration properties.

3. Fan belts should be checked for tightness and damage and changed as necessary.

4. Fans should be checked for direction of rotation. Sometimes two phases of a three-phase supply are reversed causing the fan to run the wrong way. Under these conditions a fan will only produce about 45 per cent of its design output.

5. As stated earlier the auditorium is kept under positive pressure. This can be checked by placing a lighted cigarette adjacent to a partially open exit door. The smoke should indicate an outward movement of air. If this is not the case then check for the running of supply fans and the condition of filters and heaters.

6. Radiators and convectors should be clear of obstruction. Heaters on the stage should not be turned off. They have been positioned to prevent cold down draughts entering the auditorium.

7. Oil or gas fired boiler plants will usually be maintained by a specialist firm but sudden breakdowns are often due to a failed safety circuit. Check that the oil or gas supply has not been shut down by the safety oil fire

valve or gas solenoid valve. These devices will close (in the safe position) if there is an interruption of the electric supply and have to be reset by hand.

The whole of the heating and ventilating plant will only give of its best if it is kept in good clean condition and is intelligently operated. If in doubt call in a specialist contractor to check the plant. It is a vital part of any theatre and should not be thought of as any less important because it is not in the public eye.

References

Chartered Institute of Building Services Guide to Current Practice.

Greater London Council Technical Regulations and London Building By-laws for Public Places of Entertainment.

39. SAFETY IN USING NATURAL GAS

Unattended Premises

If premises have been unattended or empty for several days you are advised to have a good sniff around before switching on lights or other electrical equipment, and before lighting up gas or other fuel burning appliances. If in doubt phone your local gas service centre (see 'Gas' in your telephone directory).

Gas Escapes

Anyone who smells gas should immediately take the following steps:–

1. Put out cigarettes; do not use matches or naked flames; do not operate electrical switches.
2. Open windows and doors to get rid of the gas.
3. Make sure that the gas does not come from a gas tap that has been left on accidentally or from a pilot light that has blown out. If that is not the cause of the smell, there is a gas leak.
4. So turn off the gas supply at the meter, and telephone your local gas centre.

   The number is under 'Gas' in your local telephone directory.

   You must not start using gas again until the leak has been repaired by a competent person.
5. If you cannot turn off the gas at the meter, or if the smell persists when you have done so, telephone the local gas service centre immediately, stressing that it is an emergency. Again you must not start using gas until the leak has been repaired by a competent person.
6. If you should happen to smell gas in the street, report it to the gas emergency service without delay.

Gas Appliances

To ensure the continuing safe and efficient operation of appliances, it is advisable for them to be regularly serviced and maintained. Regular servicing schemes are available for most gas appliances either from the local Region of British Gas (phone the local gas service centre) or from CORGI Registered installers.

Central Heating/Hot Water Boilers

The boiler, its various time and temperature controls, the radiators and valves get a lot of hard wear during the winter months. A thorough overhaul, good clean up and safety and efficiency check once a year will ensure that the heating system is running at maximum efficiency. This not only means it will give better service, but will also keep fuel bills down as the system will be using gas more efficiently. British Gas offer regular servicing schemes, and most CORGI members will also do this work, which is generally a well justified and worthwhile investment.

It is important that instructions detailing the correct procedure to be followed when lighting the boiler(s) are prominently displayed close to the appliance. These lighting instructions must always be strictly adhered to. If lighting instructions are not available (frequently they are attached to the inside of the boiler casing door) they can be obtained by writing to the boiler manufacturers.

In the event of a boiler failing to shut down under automatic control, turn off the gas supply isolating valve to the boiler and report to the local gas service centre.

In the event of the boiler failing to light up, turn off the gas supply isolating valve to the boiler, examine thermostats to ensure they are calling for heat, check that the clock or time switch has not stopped in the OFF position and then carry out the lighting procedure. If the boiler still fails to light up report to the local gas service centre.

Instantaneous Water Heaters

Instructions detailing the correct procedure to be followed when lighting the water heater should be displayed close to the appliance.

If the pilot goes out after completing the lighting up procedure, or the main burner does not light, or the water is not hot enough, report to the local gas service centre. It is important that adjusting screws and controls are only altered by competent persons, and if the water heater does not appear to be correctly working e.g. 'smells' when lit, water not hot enough, etc., this should be quickly reported to the local gas service centre.

An unflued instantaneous water heater should not be used continuously for more than five minutes and should have a label to that effect.

Space Heaters, e.g. gas fires, warm air units, overhead heaters

Once again adjustments to burners and controls must not be made by unqualified personnel. Since the flames are usually visible it should soon be evident when the heater requires attention, e.g. flame picture not uniform, heater 'smells' when lit, etc., and this should be quickly reported to the local gas service centre.

Secondary lighting and Exit Signs

The glasses of lighting fittings require cleaning regularly, usually every two weeks or so. The glasses where fitted should be removed with care and cleaned with a soft rag. At the same time if the mantle is, or appears to be, damaged this may be replaced, and it is advisable to keep a number of spare mantles available in stock. Mantles are very fragile and require careful handling.

When reassembling the lighting fitting, remember that glasses should not be a tight fit in their galleries but should have room to expand.

If attention other than cleaning glasses or replacing mantles is required report to the local gas service centre.

Other equipment e.g. gas cookers, catering equipment, refrigerators, incinerators

It is strongly emphasised that attention to these appliances should be restricted to 'good housekeeping' practice. If the appliances require servicing, adjustment or spare parts, it should be reported to the local gas service centre.

The Gas Safety Regulations 1972

The above Regulations came into force in 1972, and lay down responsibilities and legal requirements for the installation of pipework and gas appliances, the use of gas, and the removal, disconnection, alteration, replacement and maintenance of gas fittings, etc.

To meet these legal requirements and responsibilities it is advisable to employ either British Gas or a CORGI registered installer to carry out servicing and installation work.

Part VI of the Regulations covers the 'Use of Gas' by individuals and is reprinted below.

Extract from the Gas Safety Regulations 1972:

Part VI Use of Gas

47. No person shall use or permit a gas appliance to be used if any time he knows or has reason to suspect –

(a) that there is insufficient supply of air available for the appliance for proper combustion at the point of combustion;

(b) that the removal of the products of combustion from the appliance is not safely being carried out;

(c) that the room or internal space in which the appliance is situated is not adequately ventilated for the purpose of providing air containing a sufficiency of oxygen for the persons present in the room or in, or in the vicinity of, the internal space while the appliance is in use;

(d) that any gas is escaping from the appliance or from any gas fitting used in connection with the appliance; or

(e) that the appliance or any part of it or any gas fitting or other works for the supply of gas used in connection with the appliance is so faulty or maladjusted that it cannot be used without constituting a danger to any person or property.

48. (1) If at any time any person supplied with gas by an Area Board knows or has reason to suspect that any gas is escaping in the premises supplied with gas he shall immediately shut off the supply of gas at such place as may be needed to prevent the gas from escaping.

(2) Where any gas continues to escape in any premises after the supply of gas has been shut off, the person supplied with gas shall as soon as practicable give notice to the Area Board of the escape.

(3) Where any gas escapes in any premises supplied with gas and the supply of gas is shut off, the supply shall not be opened until all necessary steps have been taken to prevent the gas from again escaping."

Contacts for Gas Service or Installation Work

1. To contact your local gas service centre, look under 'Gas' in your telephone directory.

2. To contact a CORGI installer you should get in touch with one displaying the 'Corgi Registered Installer' sign — alternatively a list of local installers may be obtained from:

   The Director
   C.O.R.G.I.
   140 Tottenham Court Road,
   London W1P 0AS

16mm Practice

40. THE 16 mm SOUND PROJECTOR

Fundamentally, a 16 mm projector is like any other projector for motion-picture films. There are many differences, however, and they are more than skin deep. They arose from necessities and they continue because these necessities still prevail.

That 16 mm projector design should diverge from 35 mm design at the time when the first narrow-gauge projector was conceived more than half a century ago was due to three factors. It would use "safety" film – which simplified the designer's task. It would be operated in unventilated rooms – which excluded carbon arcs as a light source (even if their light output had been needed for the applications envisaged at the time). It would be operated by unskilled personnel.

The designer's response to these factors will become clear as the basic sub-systems which make up a modern 16 mm sound projector are described.

Light Sources. Until a few years ago the light source was – except in a minority of projectors intended for big-screen applications – a gas-filled tungsten-filament lamp. Many of these projectors are still in the field and the operator should note that they are of two types:

1. Those in which the lamp filament is supplied with its working voltage (usually 110V) through an internal or external transformer which must be adjusted to suit the local supply.

2. Those which operate at line voltage and are therefore connected directly to the local supply through the projector switchgear. Over-volting has such a harmful effect on lamp life that the lamp should correspond as closely as possible to the supply voltage. This should present no problem. In one current catalogue, for example, the widely used 750W A1/53 is available for 115, 220, 230, 240 and 250V.

Most lamps in the above categories are 750 or 1000W and have an average life of 25 hours. They require a reflector within the projector for maximum light output.

The separate reflector became unnecessary with the introduction of "proximity reflector" lamps, such as the A1/207, with internal aluminised mirrors. These have a special "valve type" base with a central locating peg and are not, therefore, usable in unmodified projectors designed for the older lamps.

A further development was the introduction of a special class of tungsten-halogen lamps as direct replacements for proximity reflector lamps. Although less efficient in terms of lumens per watt than the low-voltage tungsten-halogens of modern projectors, they give a somewhat higher light output than the equivalent proximity reflectors and a useful doubling (to an average of 50 hours) of life. Available types include the 750 W A1/256 and the 1000W A1/242.

All of these high-voltage lamps have delicate filaments and projectors should be handled with particular care while they are hot.

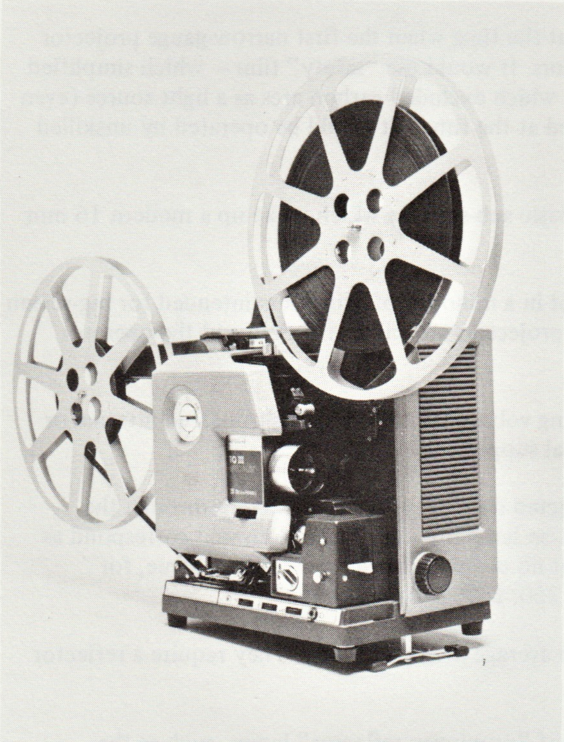
Today's portable projectors are designed almost without exception for low-voltage tungsten-halogen lamps, 24 V, 200 W and 24 V, 250 W being the customary choices for 16 mm. These, of course, require a step-down transformer, almost invariably mounted within the projector and also supplying, through separate windings, appropriate voltages for the driving motor and sound system.

The low-voltage tungsten-halogens are used in conjunction with dichroic mirrors coated in such a way that reflection is selective, favouring visible light, which goes forward into the projection aperture, and partly rejecting the unavoidable component of radiant heat. Dichroic reflectors may be part of the projector (eg with the A1/235) or integral with the lamp (eg A1/258); integral reflectors are increasingly preferred by projector manufacturers. The surface coating of any dichroic reflector is delicate and easily damaged; cleaning by the user is inadvisable and, if attempted, should be confined to the removal of dust with a soft brush.

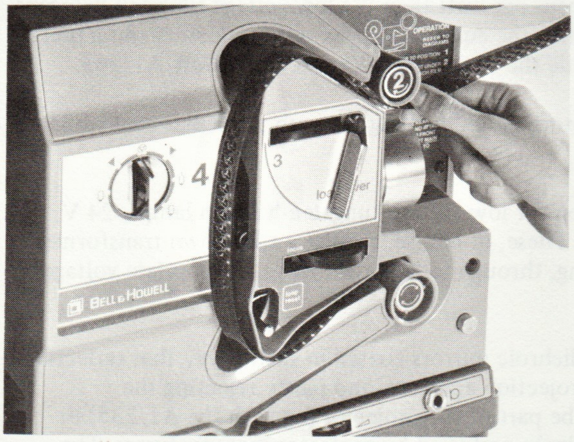
When handling tungsten-halogen lamps, great care should be taken not to touch the bulb with bare fingers as this may cause premature failure. A bulb accidentally touched should be cleaned immediately – even if no fingermarks are visible – with surgical or methylated spirit.

The life of a low-voltage tungsten-halogen lamp is typically 50 hours at full brightness. As modern projectors have a greater light output than many users need, several manufacturers fit an "economy" switch which allows the lamp to be run at a reduced voltage. This gives, in return for a small drop in light output and colour temperature, approximately double the running life. Advantage should be taken of this feature not only for economy but also because a picture is degraded if excessively bright.

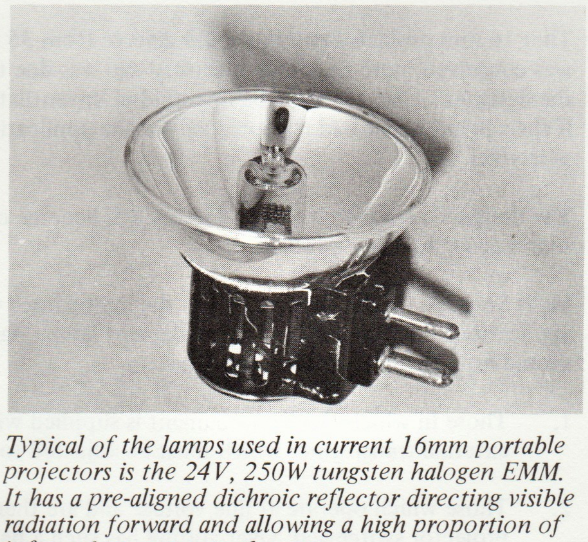
Projectors designed for screens larger than can be satisfactorily lit with a filament lamp originally used carbon arc lanterns identical to or derived from those used for 35 mm. Today, these have been superseded by discharge lamps of the "Marc" or xenon type. Both require additional power packs to provide a high-voltage pulse to strike the arc and a ballast to limit the operating current and both should be used in accordance with the projector manufacturer's instructions. The life of "Marc" lamps is seriously affected by switching on and it is advisable to do this only once during each performance. For this reason manufacturers provide an in-built dowser allowing the lamp to remain on during threading or intervals during the presentation.



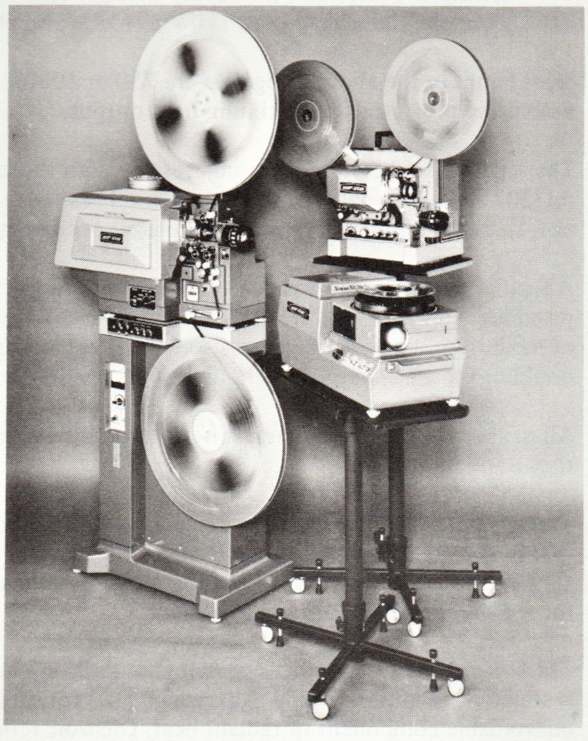
A current 16mm projector with automatic threading, an automatic loop reformer and a manually operated device for resetting loops while running.



A 16mm projector of the 'channel loading' type. The film can be threaded or unthreaded in mid-spool.



Typical of the lamps used in current 16mm portable projectors is the 24V, 250W tungsten halogen EMM. It has a pre-aligned dichroic reflector directing visible radiation forward and allowing a high proportion of infra red to escape to the rear.



For larger picture presentation, 16mm projectors are fitted with the Xenon arc lamphouses shown here, for both permanent and portable installations.

The majority of projectors are built on the assumption – justified by experience – that lamps are prefocussed to a sufficient degree of accuracy by the lamp maker. If a projector has user adjustments for lamp position, they should be used in accordance with the instruction manual. The aim should be good light distribution on the screen and the avoidance of coloured areas at the corners.

Film Transport. Between the two spools, film is transported at uniform speed by sprocket wheels with teeth on one side only – the right as the operator faces the screen. This is because 16 mm sound film has perforations along one edge, the other being occupied by the optical or magnetic sound track.

The first sprocket wheel draws the film from the supply spool into the projection aperture through the upper loop required to provide a reservoir of film for the intermittent system. The second, below the projection aperture and through a further loop, converts the intermittent motion back into the continuous motion required at the sound head. The size of the lower loop is critical. It should be set to give a total of 26 picture frames between the projection aperture and sound-scanning point in order to achieve accurate sound/picture synchronisation (for magnetic sound, the standard separation is 28 frames).

A third sprocket wheel (or the lower half of the second sprocket wheel) draws the film past the sound head. It is then wound on to the powered take-up spool, usually running over one or more snubber rollers added to prevent irregular rotation of the spool from affecting the sound or straining the perforations.

The rear spool, with its stock of film continually increasing in diameter, must have suitable torque over a range of rotational speeds. In portable projectors, the spool spindle is driven by the projector motor through a friction clutch, sometimes aided by a gravity-operated device, such as a belt, which increases torque in proportion to the growing weight of the spool. On some projectors for static installations, and on long-play attachments, the clutch system may be replaced by a torque motor which, responding to a loop sensor, maintains constant tension throughout.

The provision of powered rewinding is invariable on portable machines but on early designs may entail interchanging the front and rear spools. After rewinding, the loaded spool should be brought gently to rest; surface marks are made on the film when there is slippage between adjacent layers as a result of violent deceleration.

The intermittent system. The pull-down of successive frames, as in 35 mm, is prevented from showing on the screen by a rotating shutter which interrupts the light beam while the film is in motion. Shutters waste light and the designer accordingly makes the obscuration time, determined by the blade angle, as brief as practicable. The limit is set by the interval needed to replace one stationary frame in the projection aperture with the succeeding frame. Here, compromises are made. A very fast pull-down, while desirable on grounds of light output, subjects the perforations to undesirable stress and the audience to an excess of intermittent noise. The best modern designs achieve a pull-down which is both brief overall and quiet by accelerating and decelerating the film comparatively slowly but moving it at high speed at the mid-point of the cycle.

Although only one shutter obscuration per frame is needed to prevent the projection of a moving image (seen as a "travel ghost"), at least two are required to avoid unpleasant flicker on the screen. As flicker is apparent until there are approximately 48 obscurations per second, projectors designed wholly or mainly for silent films (16 or 18 frames per second) had three-bladed shutters providing three obscurations per frame. Silent films are so little used today that these light-wasting shutters have been largely superseded by two-bladed types, one blade interrupting the light during the pull-down and the other while the image is on the screen.

At the present silent speed of 18 frames per second, the degree of flicker with a two-bladed shutter is generally regarded as acceptable, becoming pronounced only if the picture is abnormally bright.

The device used to move the film is almost invariably a cam-operated claw. Depending on design, the claw moves forward to engage with the perforations on every downward stroke, on every alternate stroke, or on one stroke out of three (the latter practice, found on some older designs, giving the fastest pull-down speed but with a perceptible "click" as each perforation is engaged).

The claw needs only one tooth to move the film but it is normal to provide two or three to ensure film transport if, respectively, one or two perforations are broken. Only one claw makes contact with the film. As it will do this 86,400 times per hour, however, its working surface is often reinforced with an insert of Stellite or an artificial jewel. Even with this protection, the tooth may in time develop a notch on the under side. This, during insertion and withdrawal, causes perforation damage. At the first sign of roughness along the perforation edge of the film as it emerges from the projector, the claw should be inspected and, if notched, replaced.

An adjunct to certain intermittent systems is an automatic loop reformer designed to pull down a frame when, because of broken perforations, the claw has failed to do so. Operating in response to a shortened lower loop, the loop former will be synchronised with the intermittent mechanism so that its pull-down stroke occurs during the time the claw teeth are disengaged from the perforations. Projectionists should note that a loop former is unlikely to operate correctly if perforation damage is encountered while the film is running in reverse. Reverse projection should not be attempted if the film is known to have damaged perforations.

Optical System. Projectors designed for conventional tungsten-filament lamps had an optical system comprising reflector, one or two condensers and a projection lens (objective). In the newer machines with tungsten-halogen lamps and dichroic reflectors, condensers are not required.

The objective, with which the picture is focused on the screen, will on a standard machine have a focal length (F) of 50 mm. Other focal lengths are invariably obtainable from the manufacturers for special applications – a typical range extending from 16 mm (useful for rear-projection units) to 100 mm. Lens apertures have become progressively wider; the customary f/1.6 of a 50 mm lens a few years ago is frequently f/1.3 or f/1.2 today, with a consequent improvement in light output.

The mobile projectionist, giving performances with screens and halls of different sizes, can equip himself with lenses of several focal lengths (see Appendix for the necessary formulae). The alternatives are to use a zoom objective (typical range 35-65 mm) or to fit a zoom attachment on the standard objective. Such attachments have a limited range, and absorb some light, but if the projector/screen distance is approximately right they are a quick way of making the picture fit precisely.

Anamorphic lenses or converters, giving the 2:1 horizontal expansion required for 16 mm CinemaScope and similar prints, are also available. Compatibility between any anamorphic and any projector should not be assumed. Consult the manufacturer's literature, or a well-informed dealer, before making a purchase.

Objectives (and condensers if fitted) should be cleaned from time to time. The rear element of the objective, close to the film and mechanism, can quickly become soiled with dust and oil. In cleaning lenses it should never be forgotten that the surface coating which contributes to the quality of the image is delicate and easily rubbed away. First remove all dust with a soft brush, then gently polish the lens surface with a lens tissue. Breathing on the lens may help. If this does not suffice, the tissue can be dampened with a lens-cleaning fluid. Fingerprints on any lens surface should be removed without delay.

Associated with the optical system will be some form of framing control, provided to mask the projected image correctly if, through poor printing or film shrinkage, the picture frame is not in the correct position in relation to the claw stroke. The best framing adjustments are those which alter the mid-point of the stroke or the centre line of the objective. The poorest are those which shift the aperture mask because these markedly affect the position of the image on the screen and call for a compensating adjustment of the projector's angle of tilt.

Projectors designed to show still pictures invariably have a heat filter which is automatically interposed between lamp and film when the still control is used. It may be a metal gauze, a heat-absorbing glass or, often, a combination of these. Because of the need to protect a stationary frame of film from overheating, the brightness of a still picture is greatly reduced. Even then, the heat usually warps the frame sufficiently to call for a slight readjustment of picture focus and a further adjustment when normal running is resumed.

The sound head. The first requirement at the point where the sound track is being scanned is that the film be running at a constant speed. Very small speed variations cause noticeable "wow", if slow, or "flutter", if fast. The lower loop, being flexible, absorbs most of the intermittent movement imparted by the claw. The remainder, and any speed modulation imparted by the sprocket teeth, are absorbed by a tight-loop system (in good designs) fundamentally similar to those fitted on professional tape recorders and by the rotating sound drum, to which a heavy flywheel will be attached.

Most of today's sound drums are passive, rotated by the film. Power assistance has been used, however, to bring them close to the running speed.

The projectionist who becomes aware of wow or flutter can often identify the source by looking for some part which is rotating in synchronism with it. A very slow variation could be the result of a warped rear spool. A fairly fast one could come from a small idler roller which needs lubrication. These two causes can be remedied on the spot. Others, including an idler which has stalled in the past and then developed a "flat", call for workshop attention.

The sound track, if optical, will be scanned by an exciter lamp. This will be a low-voltage pre-focus lamp (except in certain old designs where stray light from the projector lamp was used), energised in modern projectors by an oscillator in the ultrasonic range or smoothed DC.

Through the sound optic – a small lens system – the light from the exciter lamp will be formed into a horizontal slit so that no more than half a wavelength of the highest recorded frequency the projector is intended to reproduce is illuminated at any time. The focusing of the slit and its horizontal (azimuth) adjustment are critical and, except on the rare projectors with user (as opposed to workshop) adjustments, should not be attempted without test films and the appropriate instruments.

The modulated light from the sound track falls on a photo-conductive device, almost always solid state in today's projectors, where it is converted into its electrical analogue for amplification.

Magnetic heads, unlike optical heads, make physical contact with the sound track, in this case "striped". The gap between the pole pieces serves the same purpose as the optical slit and the coil as the photo-conductive device. Some magnetic heads can be removed from the projector and replaced with half-track heads which allow half the width of the original optical sound track to remain usable; some are fixed.

Amplification. Except for the special circuits needed for equalisation, projector amplifiers are similar to conventional audio amplifiers of equivalent output power. On portable projectors they are invariably built in. Today's amplifiers are solid state, with discrete diodes and transistors or integrated circuits or a mixture of each.

Many projectors have a small loudspeaker built in but these (not least because the sound will come from the wrong place) are unsuitable for large audiences. Separate speakers with a greater power-handling capacity (sometimes built into a removable side cover) are invariably available either as part of the projector or as optional accessories. Alternatively, speakers of special types such as line source can be connected if correctly matched to the output impedance (which may be 4, 8, or 16 ohms) of the projector amplifier. The internal speaker (except when wired as a monitor) will be automatically muted when an external speaker is plugged in.

There is now a welcome tendency, even on portable projectors, to provide a low level "line" output in addition to the normal audio output, allowing connection of the projector sound system to a house amplifier.

Faults on modern projector sound systems are uncommon, being confined mainly to an occasional failure of the exciter lamp and, through some accident in a darkened auditorium, an open-circuited speaker lead. If a loss of volume is experienced, the first place to look is the sound head. Fluff may have partially obscured the optical slit or (if fitted) the mirror directing the modulated light to the photo-conductive device may need to be cleaned. Particles of magnetic oxide may accumulate on magnetic heads, which should be cleaned like the heads in tape recorders, without metal tools.

Amplifier controls always include volume and in most cases tone (treble cut). The better designs provide separate tone controls for treble and bass, each providing an adequate degree of cut and boost around their flat-response positions.

Threading systems. Three entirely different methods of threading currently co-exist, and each has its enthusiastic supporters. They are:

1. **Manual threading,** in which the forming of loops and the engagement of perforations with sprocket teeth are separate operations, performed by the user.

2. **Slot (or channel) loading,** in which the film is drawn by the projectionist through a curved channel in one continuous movement. Operation of a lever then automatically forms the loops and engages the perforations with the sprocket teeth.

3. **Automatic threading,** in which the tip of the film is inserted at the front end of the film path and then transported automatically the rest of the way up to (but seldom including) the take-up spool.

The appropriate threading method largely depends upon circumstances. When it can be guaranteed that the operator will always be adequately trained, manual threading will be satisfactory and will probably cost rather less. When operation by beginners is envisaged, fully automatic threading is advisable because it is virtually impossible with a well-designed projector to make an error capable of damaging the film.

Slot loading is almost as safe for the film. Its main advantage over the other methods is that it enables the film to be speedily loaded or unloaded in mid-spool and, in some projectors, provides for fast forward and backward "searching". In certain applications, teaching and training particularly, these may be decisive arguments in its favour.

Special Systems

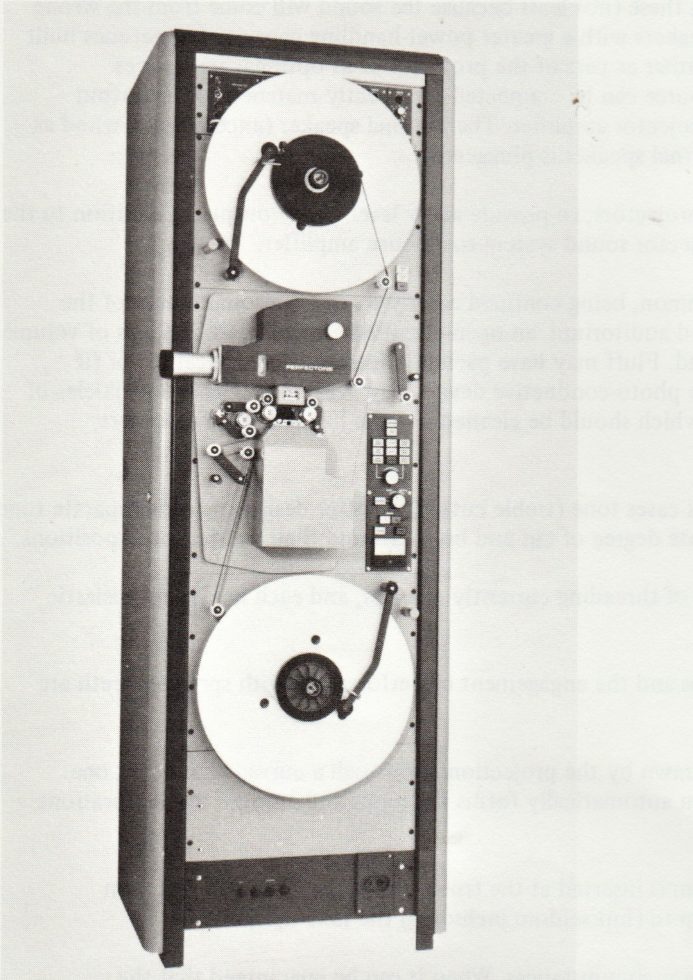
Double-band. In preview theatres, and in some other applications, it may be necessary to show a film while the sound track is still on a separate medium or "band". If this medium is 16 mm sprocketed magnetic film, fully coated or striped, a double-band projector is normally used. One side of such a machine is basically a conventional 16 mm sound projector. The other is a recorder-player for the sprocketed film. Synchronisation between the two sides is normally achieved by a direct coupling between the sprocket wheels on the two sides.

In certain double-band designs it is possible to transfer sound from one medium to the other.

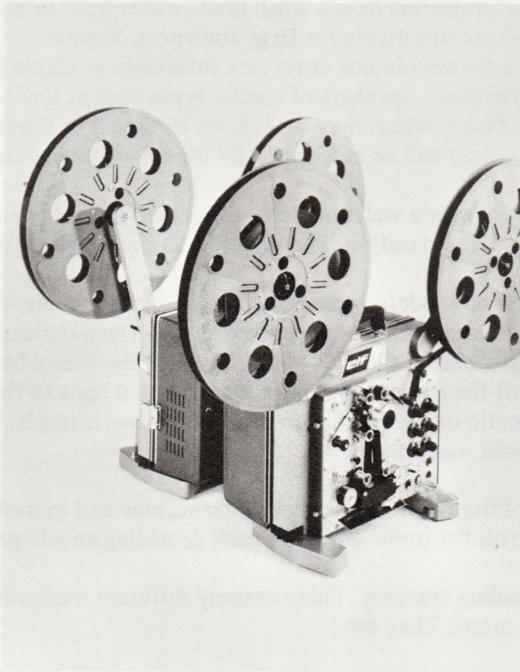
During production, double-band projectors are used to make and edit recordings before their transfer to an optical (COMOPT) or magnetic (COMMAG) track alongside the picture film. In their playback role they provide synchronised projection of a picture film and a separate magnetic track (SEPMAG).

Interlock. Synchronous running of separate picture and sound media is also achieved with a mechanically independent sound recorder/player electrically interlocked with the projector either by a Selsyn drive or pulse-controlled stepping motors. The pulse-controlled systems lend themselves well to "multivision" presentations in which films and slides are combined.

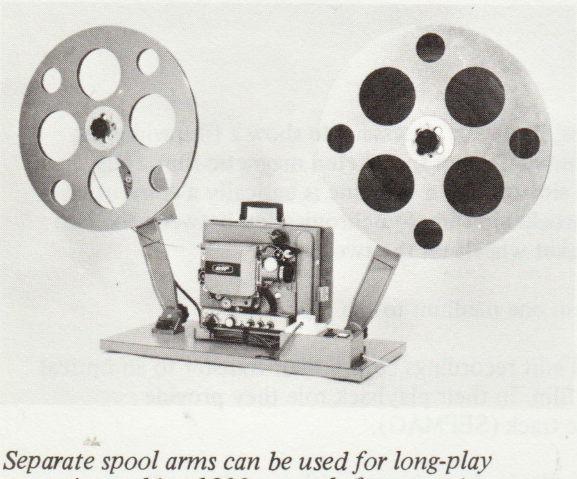
Long-run devices. Most portable projectors are nowadays designed to accept 2000 ft/600 m spools, giving a running time of 55 minutes at the standard sound speed of 24 frames per second. Accessories are available which allow 6000 ft/1800 m spools to be used, giving an uninterrupted programme time of up to 2 hours 40 minutes. The extra large spools are mounted on separate spool arms, usually with the projector between. The take-up drive is provided



The Perfectone Comitor 16mm projector for dubbing studios, using continuous motion with an optical intermittent, for forward and reverse running at all speeds from 0 to 150 frames per second.



In double-band operation a separate sound track record is run in synchronised projection with the picture film.



Separate spool arms can be used for long-play operation, taking 1800m spools for a continuous show up to 2 hours 40 minutes.

For continuous presentation, an endless loop of film can be housed in a loop-absorber system.

by a separate motor, torque-controlled on the good designs by a sensor which responds to the tension between projector and rear spool.

Continuous play. For non-attended, non-stop operation, endless loops of film are used. Very short loops can be accommodated on a system of rollers (a loop absorber); films of normal length are housed in drums (vertically or horizontally mounted) with capacities of the order of 30 minutes. For continuous-play systems of the drum type, correct lubrication of the print is essential and the splice needed to form the loop must be strong.

Continuous motion. For use in studios or dubbing theatres, where there is often a need for fast backward and forward running with synchronised sound, there are new projectors which dispense with the intermittent movement, relying solely on sprocket wheels to transport the film. They are designed to run in interlock with a variety of sound recorder/reproducers over the whole range of operating speeds from "still picture" to fast forward and backward wind.

On continuous-motion projectors, the picture frames are held stationary on the screen by a rotating prism or mirrors in the optical path. Recent developments have resulted in high light output and a picture which even on theatre-size screens has acceptable steadiness for the intended applications. The cost of these machines is high, however, and likely to remain so.

Remote control. Some manufacturers offer remote control accessories for their projectors. These range from a simple stop/start switch to an array of switches controlling the motor and lamp (and possibly still picture) in forward and reverse and can be useful to the lecturer who has to be his own projectionist. More versatile systems allowing the sound to be controlled can be custom-built by specialist companies.

Changeover devices. For dual-projector operation, certain projector manufacturers market changeover accessories. These normally extinguish the light of the outgoing machine by switching off the lamp, rather than by using a shutter, and there are various arrangements for changing over the sound and for operating the "idle" machine during threading and unthreading.

Although the 16 mm projectionist cannot rely on the presence of changeover cues (or even of a standard numbered leader) on every print he is called upon to project, cues will normally be found on prints derived from theatrical originals. A satisfactory changeover procedure (after the first spool is on the screen) is to thread the incoming machine so that the first picture frame is the same number of frames away from the projector gate as there are frames (168 or "7" on the leader) between the first (motor) and second changeover cues. The incoming machine is started at the appearance of the first cue on the screen. At the second cue, the lamp and sound of the incoming machine are switched on and the lamp and sound of the outgoing machine switched off, the outgoing motor being left running to remove the tail of the film from the system.

If there are no cues, unobtrusive changeovers can be made by threading the incoming projector with the first programme frame in or just a few frames above the gate and operating the changeover switch immediately the screen goes black. If there is time, however, the projectionist may prefer to make a discreet pair of changeover cues with a wax pencil (applied lightly) or small self-adhesive patches. Permanent marks should never be made on the film, however, and even temporary marks should be removed before the film is returned to the library.

Appendix: Lens/Screen/Throw Relationships

The basic formula relating lens focal length to length of throw to screen width is

$$F = \frac{AT}{W}$$

where

F = focal length of projection lens
A = aperture (width of mask in gate)
T = throw (projector/screen distance)
W = screen width

For 16 mm, A can be taken as 0.38 in or 9.7 mm. With F in inches (or millimetres), and T and W in feet (or metres), the formula then gives the following:–

	Imperial	Metric
For focal length:	$F = \frac{0.38 \times T}{W}$	$\frac{9.7 \times T}{W}$
For screen width:	$W = \frac{0.38 \times T}{F}$	$\frac{9.7 \times T}{F}$

For length of throw: $T = \dfrac{F \times W}{0.38}$ $\qquad \dfrac{F \times W}{9.7}$

What, then, is the required length of throw to fill a screen width of 8 ft with a 2 in lens?

$$T = \frac{2 \times 8}{0.38} = 42.1 \text{ ft}$$

And what width of screen should be installed in a theatre where the throw is 25 m and the projection lens 75 mm?

$$W = \frac{9.7 \times 25}{75} = 3.23 \text{ m}$$

For anamorphic projection, use the same formulae, making the appropriate adjustment for the fact that the width of the picture will be doubled when the anamorphic attachment or lens is in use. In the first worked example, therefore, the throw required will be only 21.05 ft for a CinemaScope print. In the second, the CinemaScope print will need a screen 6.46 m wide.

It was once customary to publish "ready reckoner" charts giving screen widths and throws at a glance. In these days of ubiquitous electronic calculators, however, it is quicker (as well as more accurate) to perform the calculation. It should be remembered, however, that projection lenses are not infinitely variable (except those of the zoom kind) but come in steps. Here, for reference, are the steps available in one leading manufacturer's range: 0.63 in/16 mm, 1 in/25 mm, 1.5 in/38 mm, 2 in/50 mm, 2.5 in/64 mm, 3 in/76 mm, 4 in/100 mm.

41. THE PRESENTATION OF 16 mm FILM

The very wide use of 16 mm films for entertainment, training and for a variety of purposes in education and industry often results in makeshift methods of presentation. Its growing use too as a production film gauge emphasises its importance.

In some instances where financial resources are adequate a much improved impact is obtained by the proper methods of presentation. The following advice will be found helpful even if the ideal method cannot be attained.

Ideally 16 mm projection should be identical to its 35 mm counterpart. Unfortunately, however this is not always a practicality. Many of the requirements will be dictated by the type of work for which it is intended. These can be categorised as follows.

Entertainment: the showing of films to an audience as in a cinema.

Professional: for post-production work within the film industry, for viewing.

Instructional: use in lecture theatres and audio visual situations.

First considerations are for a well-lit and ventilated room of sufficient size, with a main entrance and, where possible, an emergency entrance/exit.

The front wall should contain portholes for projectors and projectionist.

Projector ports should be equidistant either side of an imaginary centre line from the centre of the screen. They should be of 30 x 30 cm size, 6 mm plate glass in a metal frame fitted into a further metal frame set into the wall. The top of the frame should be angled towards the screen to eliminate reflection into the soundhead as this can cause hum problems. The port should be of sufficient height from the floor to accept the optical centre of the projector: 1.4 to 1.5 m will generally suffice but allowance must be made for projector rake.

The observation porthole is of the same construction, 6 mm plate glass in a metal frame but need be only 23 x 23 cm square. It should be fitted 45 cm to the right of the projector port and 23 cm higher. There should be one observation port to each projector port.

Working space between the projectors should be no less than 0.75 m – more if possible. Ample space above and in front of the projector to accommodate the larger reels now in use must be considered.

In situations where both 16 mm and 35 mm projection is envisaged, then the 16 mm projectors should take pride of place in the centre of the room. The reason for this is the greater degree of magnification required for the 16 mm frame. In other words, if the 16 mm projector is too far off the screen centre line, one side of the picture will be out of focus in relation to the other side.

Adequate lighting in the projection room is of the utmost importance. There must be at least one general lamp operated from switches at the entrances. Other lamps, preferably ceiling pendants, should be sited over each observation port, with individual local switches, either ceiling pull-cord or the small dimmer switches which are currently available. The rewind bench will also require individual lighting as will any other equipment position.

Electrical supplies will be dictated by the type of projector but generally a 2 gang 13 amp switched socket outlet under each projector port will be sufficient. Other 13 amp outlets should be positioned where they will be of most use.

The position of controls for such things as moveable masking, curtains and house-lights tend to become a problem. They should be mounted immediately to the projectionist's hand, somewhere between the machines on the front wall, perhaps even duplicated at the other projector.

The projection room will certainly need ventilation of sorts and how this is accomplished will depend on the construction of the projection area but there must be fresh air circulation, either natural or forced.

The projectors will produce a fair amount of heat and, in the case of Xenon lamps, will produce ozone each time the lamp is struck. This will be pleasant or unpleasant according to individual taste, but it can cause headache and nausea, and indeed, ozone poisoning when taken in sufficient quantities.

Decoration of the projection room is of prime consideration. It should be light and cheerful, giving the impression of space and cleanliness. There is no need for complete matt black interiors or front walls, and dark colours should not be used.

Floor covering should be lino, tiles or some other such easy-clean material and should be kept clean.

16 mm film is non-inflammable but as in any room containing electrical equipment, suitable fire precautions should be observed. Fire extinguishers of an approved type for electrical fires and fire-blankets are to be preferred to the bucket of water and sand-bucket which are apt to be neglected.

Projection Room in the Studio

The Studio projection room will already contain 35 mm projectors equipped with clover leaf attachments for running separate picture and sound track, either optical or magnetic. A dubbing theatre will also have a number of separate magnetic play-back machines, 16 mm or 35 mm. These will be electrically interlocked with each other and with the projectors to enable multi-track recording. The 16 mm projectors in this type of installation will be "double headed", able to run separate picture and sound-track, which will be 16 mm magnetic film, able to accept a number of sound tracks.

The separate magnetic track, or SEPMAG, may be fitted to the opposite side of the projector or may be custom built underneath an especially modified machine, the important feature in both systems being the drive arrangement which must keep picture and soundtrack in synchronism.

The Audio Visual Projection Room

For audio visual presentations, requirements will be quite different. In addition to 16 mm projectors, there will be at least one, but probably more, 35 mm slide projectors. These machines may be linked with a tape recorder for fully automatic single or multi slide presentations and will also be capable of remote control from the lecturer.

In addition there will be a public address amplifier with comprehensive mixing facilities, to enable fixed and movable microphone positions to be used, plus radio microphones, tape recorders and record-playing equipment.

In this type of projection room it has become common practice to dispense with individual port-holes and to use a glazed slot running the length of the room. This would be all very well if both projectionists and equipments all had the same optical centre: unfortunately this is not so and the practice can cause considerable problems. To overcome these some designers specify large picture windows but this also causes a problem, which applies to the slot window, but in a lesser degree. The projectionist has to work in complete darkness because of the amount of light escaping into the auditorium. When he is able to use the projection room lighting he is troubled with reflection in the glass and cannot see what he is doing.

Concurrent with these situations is the practice of building one long shelf under the port to support the projectors. while this is quite suitable for the slide and film strip projectors it is not practical for 16 mm projectors: it makes them impossible to operate properly.

Portholes should be as previously mentioned, 30 x 30 cm for projectors, 23 x 23 cm for observation. Slide projection and mixing positions can be taken care of either by 60 x 60 cm or 30 x 60 cm. These again are standard ports within the industry and can be fitted with shutters or blinds when not in use.

The points regarding socket outlets, position of controls and projection room lighting are very important in this type of situation and designers, builders and electrical contractors should be made aware of this at an early stage of building.

All the equipment mentioned in this short study plays an important part in Industry, Education and Entertainment. It is all precision equipment and there is absolutely no reason why it cannot be contained within a precise environment, the projection room.

42. 16 mm PRESENTATION WITH A PORTABLE PROJECTOR

The good 16 mm projectionist observes the same "golden rules" as his 35 mm and 70 mm colleagues. Let nothing you do (or fail to do) distract the audience from what the film is attempting to communicate. Make all your operations unobtrusive, regarding the fact that it occurs to nobody to thank you for your efforts as the highest compliment an audience can pay.

In many of the locations where 16 mm portable projectors are used, these simple precepts are not easy to observe. The 16 mm projectionist, seeking perfection in a makeshift auditorium with echoing walls, a bare screen and the projector standing exposed in a clearing between the seats may well envy the man behind optical glass in the automated projection box of a modern theatre. Real difficulties do confront the projectionist with a professional concern for showmanship but they can all be alleviated and most can be overcome. Here are some tips.

Arriving on site. Make sure that the equipment is complete: films, projector and lens, projector stand, spare lamps, spare fuses, take-up spools, power cable, speech cable and a brush for cleaning the gate. Any can be forgotten and all – possibly excepting the projector – have been.

Arrange projector, screen and seats (if you have the options) so that the picture fits and there is a good view for every member of the audience. An ideal seating layout (Fig 1) puts the front row about two screen widths from the screen and the back row no more than six screen widths away, with the seats confined to a sector of 30° on either side of the projector/screen axis.

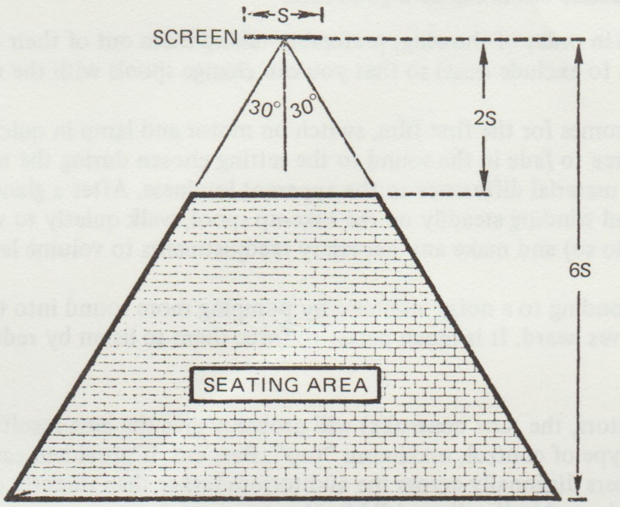


Fig.1

Check that the projector and screen are high enough for the beam of light not to be interrupted by the heads of a seated audience but don't have the screen needlessly high: it's more comfortable to look straight ahead than up in the air.

If possible, put the loudspeaker(s) alongside the screen and at about two-thirds of the screen height: sound will be absorbed – high frequencies particularly – if it is aimed at people's feet.

Arrange power and speech cables so that there is the minimum risk of their becoming tripwires in the dark. Anchor them to the legs of the projector stand so that, if feet do become entangled, the projector is not dragged to the floor.

It may not be possible to achieve an altogether satisfactory dim-out of the auditorium but look for places from which stray light may fall on the screen (remembering that the sun moves in the sky) and degrade the picture. Some black drapes, with drawing pins and sticky pads to suspend them, are a useful part of the mobile operator's kit.

Still more useful – indeed, indispensable – is a torch. In all sorts of emergencies, and for routine checking of the film for scratching during the presentation, it will be required.

Liaison. If the location is unfamiliar, there are questions to be asked of its custodian. What is the supply voltage? Where are the fuses supplying the wall socket you intend to use? Where are the switches for all the auditorium lights? Are there doors to be kept open and others which can be locked? (The fewer opportunities there are for unauthorised entry during the performance, the better it will be.)

Liaison of another kind is usually desirable. Who will be in charge of the presentation? Find him or her and make sure you know the order of the programme, what speeches there will be, and what cues are going to be given to you to begin the film or films. During this discussion make a firm arrangement for turning the house lights down and then up again at the appropriate time. Try not to agree to handle this yourself. Even if the switches are within reach of the projector stand, there are plenty of other things to be done, calling for your particular skills.

Remember that the sight of a bare screen is unpleasing. If there are curtains, you may be able to keep it hidden until projection begins. If not, turn off house lights near the screen (or, if these cannot be turned off independently, try removing a few of the more offensive bulbs). If the auditorium lighting is dimmer controlled, make use of the facility but not until a test has been shown that, when dimmed, the system will not break through on your sound. A pleasing effect can be gained by bathing the screen in coloured light while it is not in use: three or four coloured bulbs in boxes on the floor or stage are a refinement from which any show will benefit. For some but not all shows, recorded music played through the projector amplifier will help (but don't forget copyright and the need for a licence).

Dress rehearsal. There will seldom be time to run through the complete programme before the audience arrives, and this is hardly necessary, but in fairness to the audience and your reputation a few minutes of film must be projected during the setting-up phase. Only this way can you aim the projector properly from a position where the focused picture precisely fills the screen masking and find – from somewhere in the auditorium, not near the projector – an approximate setting for the volume control. Run the film back to bring the first frame of the title somewhere between the feed spool and the projector gate. Note the position of the volume control, then turn it down.

It is a mistake to rely on the unaided eye when focusing unless your long sight is first class. A picture that looks sharp from the projector may seem irritatingly soft to people nearer the screen. It may seem eccentric to peer at the screen through low-power binoculars but it can be a good idea.

Finally, arrange any other films in order of showing, preferably taking them out of their cans or cartons (though keeping the leaders taped down to exclude dust) so that you can change spools with the minimum of delay and noise.

The first spool. When the cue comes for the first film, switch on motor and lamp in quick succession. Focus should already be correct, so you are free to fade in the sound to the setting chosen during the trial run. The presence of the audience, however, can make a material difference to the apparent loudness. After a glance to satisfy yourself that the film is running correctly, and winding steadily on the take-up spool, walk quietly to various parts of the auditorium (or get a helper to do so) and make any necessary readjustments to volume level.

Don't commit the error of responding to a noisy audience by pumping more sound into the loudspeaker. They will chatter louder to make themselves heard. It is much better to force them to listen by reducing the volume level for a while.

For most films and most projectors, the tone control(s) will probably give the best result at the "0" setting (flat response) or, with the simpler type of control, maximum "top". Bass cut, if provided, can be a useful way to reduce echo – as can aiming loudspeakers diagonally across the auditorium rather than directly at a flat rear wall, and pointing then slightly downwards so that "audio axis" hits the centre of the centre row.

While it will seldom be necessary to change the volume level again during the first spool, an alert and sympathetic projectionist can sometimes help the mood of the film by judicious adjustments of the tone control(s). For example, a musical sequence or certain special effects may benefit from a bass response that would be excessively boomy for speech. But remember that in almost every film clear speech is the paramount need. And remember too – the repetition is excusable because the error is so frequently made – that it is from where people are sitting, not from the projector, that the sound quality must be judged.

End of spool. An occasional glance at the feed spool will show when the film is soon going to run out. Warn your helper to be ready to bring up the lights and, unless you know there are changeover cues, keep an eye on the film as it runs off the spool. The appearance of black leader, following the last picture or title frame, will give you about half a second of reaction time to switch off the projector lamp. Turn the sound down immediately; in the sound track area of a trailer there can be a lot of noise. Keep the motor running to clear the film out of the machine if there is another spool to project. If not, switch the motor off as well and clear the projector after the audience has left. Never rewind in their presence – an injunction which means that for a multi-spool presentation a collection of take-up spools will be required.

Subsequent spools. Except in a dual-projector show with a changeover device, the synchronising leader is not required. On a manual-threading or channel-loading projector, therefore, avoid a period of motor noise unaccompanied by picture by winding most of the leader on to the rear spool before threading or loading begins, bringing the first programme frame into the space between feed spool and projector. With automatic-threading, the leader must be run through the machine. In this case, use the torch to watch the leader numbers coming off the feed spool (the arrival of "3" means that there are three seconds of film before the first programme frame) and then switch on the lamp. The leader numbers are for private information and the projectionist who ever reveals to an audience that they exist has chosen the wrong career. Even the practice of switching on the lamp, cupping the lens and counting the flashes is to be deprecated. If the projectionist can see flashes, so can the audience in a darkened hall.

It must not be assumed that a projector correctly focused during the first spool will still be in focus for the next spool, not least because the adjustment may have been altered during threading, so check it again. It may not be necessary to recheck the sound. If the volume level judged from the projector is similar to what it was during the first spool it will be similar in the auditorium, but if you have any doubts make sure.

Problems. Splices may break and lamps may fail and in both cases there will be an interruption. Whether there should also be a public apology, and who should make it, should be decided in advance. Unless the delay is likely to be long (and "long" is an elastic term best defined by the behaviour of the audience), it is preferable to say nothing and concentrate on rethreading or whatever first aid is required.

Arguments will always rage about how best to deal with a broken splice. It is common ground that both ends of the film (perhaps after unthreading/rethreading) should be brought to the exit end of the projector between the snubber roller and the take-up spool. After that, some experienced projectionists interleave the end coming from the projector with the other end by winding both on to the take-up spool, giving the spool two or three turns to secure the loose film. This, with practice, is quicker than the alternative of making a temporary job with adhesive tape.

After dealing with a broken splice, in any event, put a note in the carton or can to tell the library, or remind yourself, that the film must be spliced before the next showing. A bit of paper, slipped under the outer turn of film on the take-up spool before projection is started again, will save time in locating the break.

One category of problem raises no question about the correct action. The good projectionist will frequently feel the sprocket holes and, with a torch, examine both surfaces of the film at the exit end of the projector. If the film is being scratched or otherwise damaged, the projector must be stopped until a cure has been found, the only exception being the very rare presentation where the consequences of an interruption are likely to be more serious than those of ruining a valuable print. In fact, except on the infrequent occasions where abrasive dirt has run into the film path during the performance, scratches and strained perforations are evidence that the projector has not been properly maintained.

For inadequate maintenance there is no excuse but there is perhaps a reason. The modern 16 mm projector calls for so little care and attention that its owner may draw the wrong conclusion that it needs one at all.

By far the most important requirement is scrupulous and frequent attention to the film path. Between every performance, all areas which can make contact with the film during threading or projecting should be inspected and any dirt removed. Check particularly that the gate runners have not picked up emulsion (if necessary paring it off with a piece of plastic or wood sharpened to a chisel point), that all the rollers run freely and that grooves in the idler rollers are not choked with fluff and dust. Even between spools, spend a few seconds brushing out the gate; otherwise, fluff from the previous spool may find its way into the aperture and be projected, embarrassingly, on the screen. (If this does happen, blowing hard into the gate may, with luck, dislodge it.)

Dirt is not the only problem. Now and again, a clean projector may begin to scratch film because of a mechanical fault. There may, for example, be a burr on one of the polished gate runners as a result of careless cleaning or (and it has been known to happen) the passage of a print "spliced" with a wire staple. The operator may not be able to remedy the fault but he can reduce chargeable workshop time by pinpointing its location. An easy way to do this is to run a length of fresh filmstock through the projector and stop the machine as soon as the scratch appears at the exit end. Then, starting from this end, unthread manually. There will come a point where the scratch is no longer there. It is in this part of the projector that the damage is arising and close inspection will reveal the cause. Whether or not it is curable by the projectionist is for him to judge, depending on the nature of the fault and his experience.

Film damage can also be caused by faulty spools. Flanges too close together may pinch the film once per revolution, causing perforation strain or even breakage (and, in the case of the take-up spool, wow). Flanges with burrs on an inner surface may cause periodic chafing of the film edge, particularly during rewinding. The edge may also be damaged, on a projector that has done long service without a thorough overhaul, by grooves worn into the various stationary edge guides; these must be replaced.

Except for a drop of light oil as emergency treatment for a sticking idler roller (with the surplus carefully wiped away), modern 16 mm projectors should never be lubricated by the operator. This is not because the "lubricated for life" claims in the publicity are literally true but because a number of different special-purpose lubricants, known only to those who have the manufacturer's service manual and sometimes difficult to obtain, are required. In the absence of any contrary advice in the user instruction manual, a good rule is to return a 16 mm projector to an approved workshop for relubrication and overhaul every 1000 hours of running or once a year, whichever comes first. The reason for the annual service is that pre-lubricated bearings dry out, even if the machine is seldom used.

A periodic overhaul in workshops is desirable in any event. The operator may not notice the gradual increase in mechanical noise and, sooner or later, the inevitable reduction in picture steadiness which are among the symptoms of wear. The workshop, however, will identify all departures from the original design specification in the course of its routine tests.

After the show. Packing up cannot be done quietly, so all of it should if practicable be deferred until the audience has departed. Rewind films only to retrieve your own spools (if they are better than the library's or – the other side of the coin – to avoid foisting on a library old spools of your own which should have been scrapped). Until all spools in circulation comply with diameter standards, it may also be necessary to rewind to get a film back into the can in which it arrived. Be specially alert with the 800 ft and 1200 ft sizes, where dimensional anarchy still reigns.

Last of all, leave nothing behind – except an impression among the audience that the programme, not the projectionist, was first class.

Miscellaneous

43 BRITISH STANDARDS FOR FILM PRESENTATION.

In the motion picture industry the work of many separate technologies must be linked together to produce the picture which the audience sees on the screen: the manufacture of the original film raw stock, the cameras and sound recorders of the studio, the printing and processing at the laboratory and the final projection in the theatre. Not only must the material originated at each stage be acceptable for handling at the next step in the sequence but the final product, the release print copies, must be interchangeable from one cinema to another without difficulty and must be presented to the public under uniformly good conditions. All this means that there must be general agreement in the materials and the methods in which they are used – in other words, standardisation. For the projectionist, there must be standardisation of the dimensions of the film, of the position and size of the picture and track, of the character of the sound recording. Similarly, there must be standardisation of many features of the equipment he uses, for the conditions of screening and the conditions of the theatre.

In the United Kingdom, the body concerned with standardisation is the British Standards Institution and all the work referring to cinematography is carried out by the industry committees CMS/ of the Business Services Department. Here there are Technical Committees at which representatives of raw stock manufacturers, film producers, processing laboratories and equipment manufacturers, as well as the unions, technical associations and television interests, meet to discuss and agree what standards are required and what dimensions and characteristics shall be adopted. At the present time the currently active committees of CMS have their work divided as follows:

CMS/–/1	The Industry Steering Committee
CMS/2	Raw Stock: dimensions and labelling
CMS/3	Film Exchange, Printing and Processing, including film for Television
CMS/4	Studio Equipment
CMS/7	Glossary of Cinematograph Terms
CMS/23	Sound Recording and Reproduction
CMS/26	Cinema Screens
CMS/27	Projection
CMS/28	Spools, Shafts, Sprockets and Magazines
CMS/29	Cinema Equipment

Since the cinema industry is an international one, involving the exchange of production materials and the wide-spread distribution of copies, essential standards must also be internationally acceptable. The British Standards Institution and the CMS Committees therefore take an active part in the work of the Technical Committee on Cinematography of the International Standards Organisation (ISO), ensuring that the knowledge and experience of British technicians make their contribution and that the standards published in this country conform to established practice on a world-wide basis.

All this work on standards, both national and international, is under constant review as new techniques are developed or new practices established. Existing British standards must be updated or issued in a revised form to match recently approved international publications by ISO. At the present time the British Standards Institution has a programme to consolidate all standards dealing with cinematography, revising them in line with latest ISO issues. These will all appear under a single reference number, BS 5550, divided into a number of sections corresponding to the different film gauges – Part 1 8 mm, Part 2 16 mm, Part 3 35 mm, as well as other parts covering items common to a number of gauges. Each of these main sections is further sub-divided for different topics – raw stock dimensions, camera usage, image areas, sound and so on. A loose-leaf system of publication is being followed so that the user can built up his own selection of just those standards in which he is interested and keep it up to date as new documents are approved.

As will be seen from the following list, not all British Standards have yet been issued in the new series, but progress will be reported from time to time in the Standards Page of the BKSTS Journal. This selection covers current standards relating to cinema practice and presentation and the characteristics of 35 mm and 16 mm motion picture film which are likely to be of interest to the projectionist.

Motion Picture Film – 35 mm

BS 5550:5.1.1.–1978	Definition of Safety Film
BS 5550:3.1.1.–1978	35 mm Raw Stock Dimensions
BS 5550:3.2.2.–1978	Projectable Image Area on 35 mm prints
BS 5550:3.2.3.–1978	Position and Dimensions of picture and optical sound track on 35 mm release prints
BS 5550:3.2.4.–1978	Aspect Ratios for 35 mm motion picture films
BS 5550:5.5.2.–1978	Leaders and Run-out Trailers for release prints (NOTE: this describes the ISO Standard Leader, which is not yet in use in the United Kingdom.)
BS 4615–1970	Dimensions of metal cans for processed 35 mm film in 300 and 600 m rolls (1000 and 2000 ft)

Sound

BS 2981–1975	Dimensions of magnetic sound records on perforated film
BS 4527–1969	Dimensions of four-track magnetic sound records on 35 mm release prints
BS 5550:3.4.2.–1978	Frequency characteristics of magnetic sound recording on 35 mm film
BS 5550:7.4.1.–1978	Electro-acoustic response for cinema auditoria and motion picture control rooms

Projection Equipment

BS 1015–1961	Exciter lamps for 35 mm cinematograph projectors
BS 1590–1949	Lenses for 35 mm cinematograph projectors
BS 1964–1953	Tolerances on diameters of carbons for projection arcs, plain and copper-coated, 6 to 14 mm diam.
BS 3946–1965	Universal Sprockets for 35 mm perforated film
BS 1587–1949	Film Spools for 2000 ft release prints
BS 5550:5.12.1 – 1978	Dimensions of cores for motion picture film

Cinema Practice

BS 5382–1976	Cinematograph Screens
BS 5550:7.2.1.–1978	Screen luminance in review rooms
BS 5550:7.2.3.–1978	Screen luminance for 35 mm projection
BS 5550:7.2.4.–1978	Screen luminance for 70 mm projection
BS 1778–1951	15 amp three-pin plugs, sockets and connectors for theatres
BS 3944–1965	Colour filters for theatre lighting
BS 2560–1978	Exit Signs (internally illuminated)
BS 4218–1978	Exit Signs (self-luminous)
Code of Practice CP 1007–1955	Maintained lighting for cinemas

Further standards concerned with 16 mm practice are:

BS 5550:2.1.1.–1978	16 mm Raw Stock Dimensions
BS 5550:2.2.2.–1978	Projectable Image Area on 16 mm prints
BS 5550:2.7.1.–1978	Projection usage of 16 mm
BS 3389–1961	Lenses for 16 mm cinematograph projectors
BS 5550:2.9.1–1978	16 mm Projection Spools up to 120 m (400 ft) capacity
BS 2014–1960	16 mm projection spools up to 2000 ft capacity
BS 3801–1964	16 mm projection spools of 2400 ft capacity
BS 5550:2.11.1.–1978	Spools spindles for 16 mm projection
BS 5550:7.2.2.–1978	Screen luminance for 16 mm projection
BS 930–1962	Measurement of light output of narrow-gauge projectors
BS 3675–1963	Performance of 16 mm portable projectors
BS 5550:2.4.3–1978	Frequency characteristics of magnetic sound recording on 16 mm film

Miscellaneous Standards

BS 1985–1953 (Parts 1–5)	35 mm Test Films for checking the optical sound system of the projector
BS 1468–1971	Test Films for 16 mm projectors
BS 5115–1974	Dimensions of picture areas for film, slides and opaques for television
BS 5196–1975	Glossary of Terms used in the motion picture industry