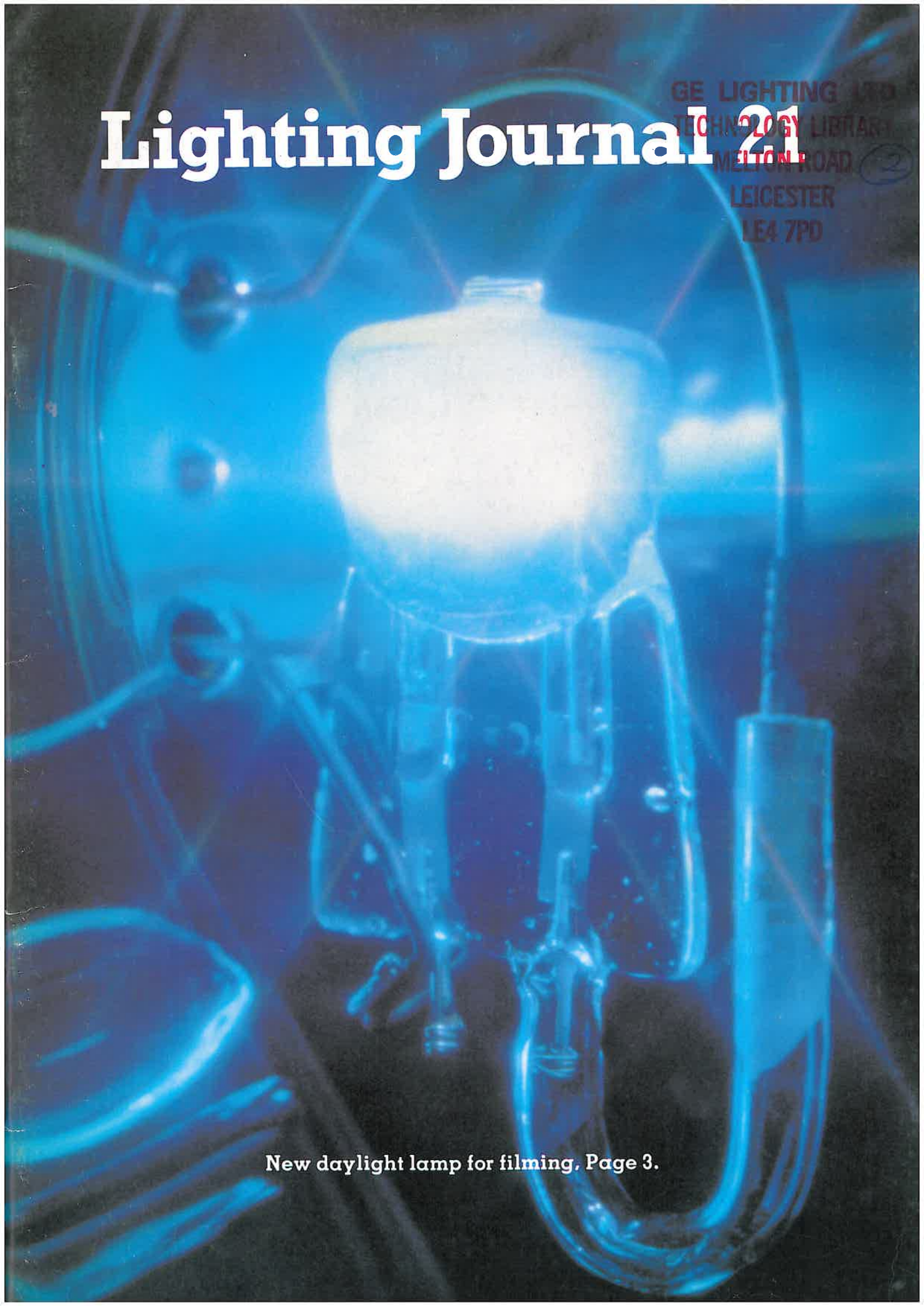
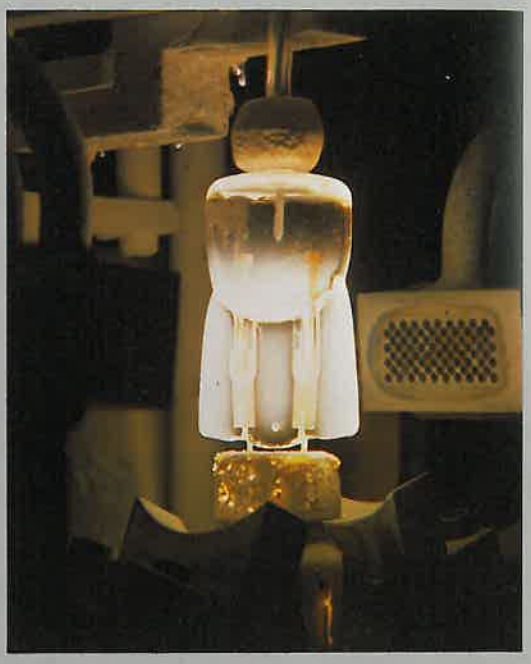
Lighting Journal 21

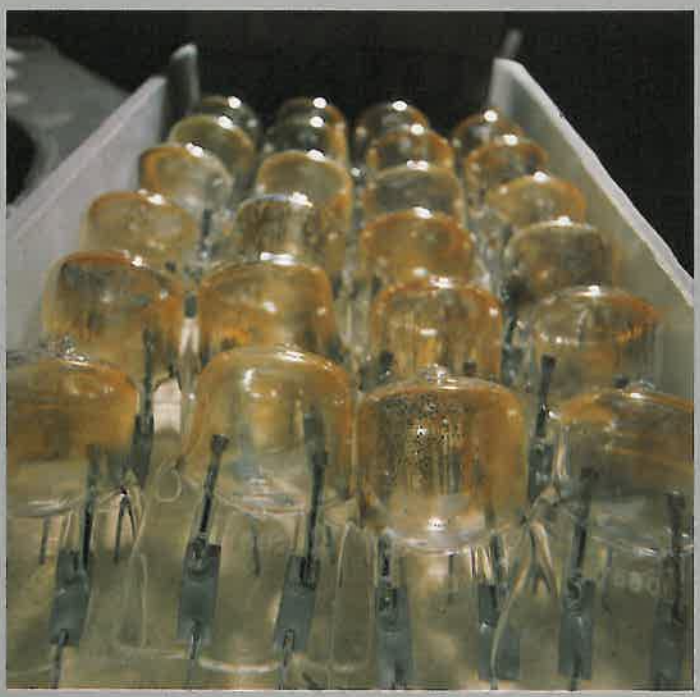


New daylight lamp for filming. Page 3.

Front cover is a close up of a PAR 64 CID lamp immediately after the arc has struck.

Stages in the manufacture of the CID lamp.





Lighting Journal 21

Autumn 1979

It is not often that one lighting company can claim the world première of a lamp, but Thorns did it some ten years ago when they produced the now world famous CSI lamp used for lighting stadia for outdoor television all over the world. Now the company has taken it a step further, first by introducing a hot restrike version of this lamp and then by developing a tin halide lamp which is especially designed for use in Film and TV studios. We make no bones about giving this important lamp development pride of place in this issue of *Lighting Journal*.

Lighting engineering is a complex subject embracing the design of and manufacture of lamps and luminaires as well as their application to buildings, streets and other locations. Articles on the techniques of testing lighting equipment for compliance with international safety standards, on the importance of industrial lighting to our national welfare and the industrial use of X-rays also find a place in this issue, and we are honoured to print a short article by Dr Marsden, the President of CIBS, on the work his department is doing for the DoE on the evaluation of street lighting.

A glance at some uses of floodlighting and work done by Thorn companies in Europe completes an issue that we hope will provide something of interest for every reader of the *Journal*.

Contents

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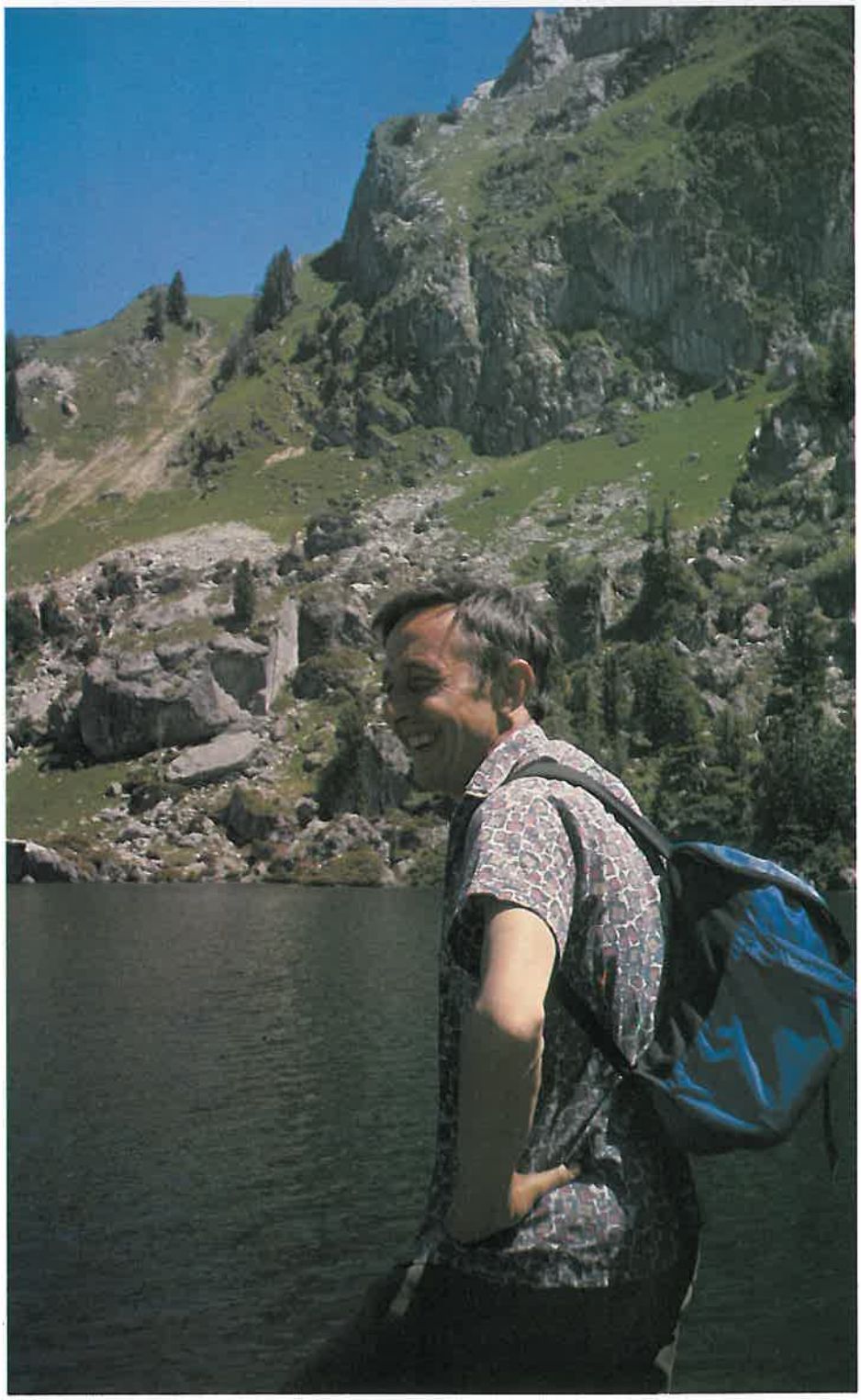


Dr Marsden on holiday in the Alps.

In the last fifteen years, Thorn Lighting has provided no less than four Presidents of the Illuminating Engineering Society; Dr Strange, Dr Ballin, Mr Hewitt and Mr Willoughby. This year, Dr "Mike" Marsden has been elected President of CIBS, the body that combines the former IHVE and IES into a single Chartered Institution.

Dr Marsden played a considerable part in the smooth amalgamation of the two societies, and during his term of office he will not only chair the Council of the Chartered Institution of Building Services, but will liaise with other Institutions advising Government on building matters as well as attending functions of the Institution, and especially of its Lighting Section in London and the Provinces.

His career in Electrical Engineering commenced when, after completing military service, he gained his BSc honours degree at Manchester in 1952. He became a lecturer at the Royal College of Military Science and went on from there to Nottingham University in 1958. He gained his MSc in 1962 for a thesis on Visual Performance and Lighting Codes and his PhD in 1968 for work on the relationship between Brightness and Luminance. He left Nottingham University in 1969, and after a visit to the USA as Visiting Professor to the College of Architecture, Virginia Polytechnic Institute, was appointed Manager, Lighting Research and Development, at Thorn Lighting and is now also General Manager of the Jules Thorn Lighting Laboratories at Enfield.

He has held some thirty-two offices in professional bodies and published as many papers and he was joint editor of the textbook "Light and Lighting" when its second edition was published in 1972.

He is married, has four children and still finds time to enjoy walking, mountaineering and music, and is assistant choirmaster at his local church at Harlow, Essex.

PAR 64, hot restrike CID lamp.

CID, a new compact source lamp for television and studio lighting.

R. Hall

Dr Hall is Manager, Advanced Engineering—discharge lamps

A new compact source, 1kW lamp has been specifically designed by Thorn for film lighting, although it will undoubtedly find application for colour television. This lamp combines the positive attributes of existing lamp designs, especially the CSI lamp, but in addition it possesses novel characteristics which are not exhibited by any other well-established discharge lamps. It is intended that the 1kW lamp will be the first of a range of compact source, iodide daylight, (CID) lamps which will be extended to both high and lower ratings.

Discharge lamps and colour television

Some ten years ago, with the advent of colour television, the discharge lamp made a major impact on the TV and film industry. The increased illumination levels required by colour TV created the demand for a light-source with high efficacy and good colour rendering and the CSI lamp was produced to fulfil this need and was used in sports stadia throughout the world. There has been much less ingress of discharge lighting into the television studios, as opposed to its use for outdoor lighting, and this can be attributed to the fact that lighting levels are more readily achieved with incandescent lamps in spite of the heat they generate which has brought beads of perspiration to many a brow. Tungsten lamps have the convenience of being able to be switched on and off instantaneously and may be dimmed over a 2:1 intensity range with only a small change in colour temperature (about 250K), a characteristic which until now has not been available with discharge lamps.

Needs of the film industry

The demands of the film industry are more stringent than those of television and are particularly pertinent to the spectral properties of the illuminant. Whereas the colour appearance of a TV picture may be adjusted electrically by varying the relative gain controls on the TV camera or TV set, much less flexibility is available when filming. Two types of filmstock are used; indoor film corrected to a colour temperature of 3200K, appropriate to tungsten filament lighting, and daylight film corrected to 5500K for location filming.

Two sources currently in use

The two major discharge sources which are presently used for CTV and film lighting are the Thorn CSI lamp and the European HMI compact source lamp. The rugged sealed-beam construction of the CSI lamp is particularly suited to the lighting of sports stadia, although its exceptionally high beam intensity has also led to its widespread use in location filming. With a colour temperature of approximately 4000K, it is readily filtered to be compatible with either type of film stock. The HMI lamps were developed to meet the need established by the German Federal Television System. Although their initial application was for outdoor TV, their use has now spread to location lighting for films where the colour temperature of 5600K is appropriate for daylight filmstock.

The Lamp Design

The inherently robust construction of the CSI lamp is reproduced in the CID lamp which closely resembles it in appearance. The arc tube, which has a silica body, uses a single pinch to position the electrodes 14mm apart. It is filled with a combination of mercury with tin and indium halides, chosen to produce a spectrum closely resembling that of

The Thorn CID lamp compared with an HMI lamp. (bottom) The standard and hot restrike CID lamps.

daylight at 5500K. The halide dose is completely evaporated during lamp operation and this results in the electrical and photometric characteristics of the lamp being much less dependent on the temperature of the arc tube than is the case in lamps which use a saturated vapour pressure, as for example rare earth halide lamps.

Earlier attempts to produce a tin halide lamp have mainly been concentrated on a lamp suitable for interior lighting with a large gap between the electrodes. Such lamps have suffered from arc bowing when operated in the horizontal position and arc instability or "snaking" when burnt vertically. Earlier work has also shown that the tin halide lamp is sensitive to trace quantities of oxygen and hydrogen. However, as a result of the effort that has been concentrated on tin halide lamps at Thorn Lighting over the past decade, improved processing techniques are used in the new range of CID lamps, so overcoming these problems.

Lamp construction

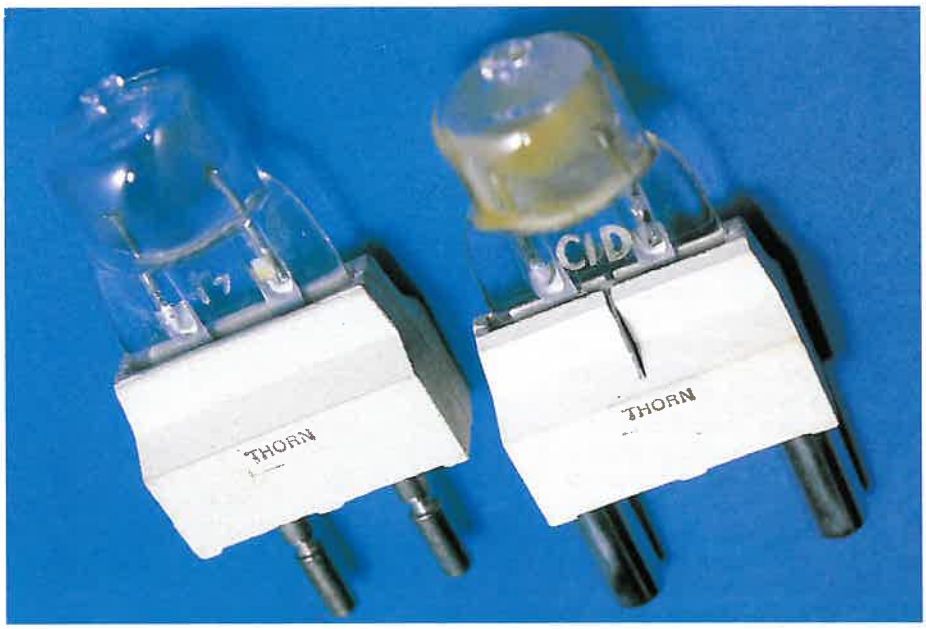
In its unjacketted form, the lamp, is housed in an unglazed ceramic cap with a bipin base. This construction makes mounting and replacement on site a simple matter compared with double-ended designs of lamp. The small size of the lamp allows most existing lanterns to be adapted to accept it. There may be a requirement for both hot or cold restrike capability depending on the specific application. The standard "cold start" lamp is constructed on a G22 base, but this is inadequate to withstand the 30kV pulse required to achieve a hot restrike without the possibility of tracking between the leads. The hot restrike lamp uses a G38 bipin base and the risk of tracking is overcome by slotting the quartz pinch and inserting a mica preform held in position by a corresponding slot in the cap.

Sealed Beam construction

Although studio lamps mounted in PAR sealed beam constructions have been common in the USA for many years, they are only slowly gaining ground in the United Kingdom. The CSI lamp, mounted in the PAR64 reflector has proved itself as an

CHARACTERISTICS OF 1KW HOT RESTRIKE CID LAMP

Electrical	Arc Voltage	– 70-85
	Nominal Arc Current	– 15 amp
	Run-up Time	– 1 minute
	Re-Start Time	– Instantaneous
Bare Lamp	Arc Length	– 14 ± 1.0
	Lumen Output	– 70,000
	Lumen Maintenance	– 90%
	Correlated Colour Temp.	– 5500 ± 400°K
	General Colour Rendering Index Ra	– 85
	Rated Life	– 500 hours
Sealed Beam Lamp	Peak Initial Beam Candlepower	– 850,000 cd
	Beam Width (½ peak)	– 8°
	Field Angle (1/10 peak)	– 20°
	Correlated Colour Temp.	– 5500 ± 400°K
	Colour Rendering Index Ra	– 85
	Rated Life	– 1000 hours



efficient high-intensity light source suitable for stadia lighting and for outdoor television and filming. It is expected that the CID lamp mounted in the same sealed beam jacket will be equally successful for studio and location filming. Although the standard cold-start type of lamp is available, it is anticipated that the major studio requirement will be for the "hot restrike" lamps. In this design, a dichroic reflecting surface is used which reflects visible radiation but transmits infra red; not only do the insulating properties of the dichroic coating eliminate the possibility of flashover which would occur with an aluminised reflector during restart, but it also produces a cooler beam.

Electrical Characteristics

The 1kW CID lamps are designed to operate at a lamp voltage of 70-85 volts but a nominal current of 15.0 amps, using the ballast and ignitor which are currently used to operate the CSI lamp and are described in the following article in this issue. The electrical characteristics of the CID lamp are shown in fig. 1 which indicates the dependence of the lamp power, voltage and current upon changes in supply voltage when it is operated on a simple choke ballast.

The transient characteristics of the lamp from a cold start with the choke ballast are shown in fig. 2. It can be seen that the lamp attains 90% of its full lumen output within one minute. If the lamp is warm when ignited, an even shorter run-up time can be achieved. For instance, tests on a fully run-up hot restrike lamp show that if it is switched off for one minute and then re-ignited, it will attain 50% of its light-output within five seconds and 90% within approximately 20 seconds.

The rated life of the unjacketted lamp is 500 hours, and that of the encapsulated type is increased to 1000 hours.

Lumen Maintenance and Colour Stability

As shown in the table, the nominal efficacy of the 1kW CID lamp is 70 lumens per watt, and the maintenance throughout life is better than 90%. This excellent lumen maintenance is associated with the well-documented tungsten halogen cycle which prevents tungsten evaporated from the electrodes being deposited on the walls of the arc tube and attenuating the light output. The lamp efficacy is relatively insensitive to the power dissipation of the lamp. This is shown in fig 3, which illustrates the linear dependence of lumen output on power dissipation. Over the wattage range indicated, (700-1150) the lamp colour is constant within measurement error. This

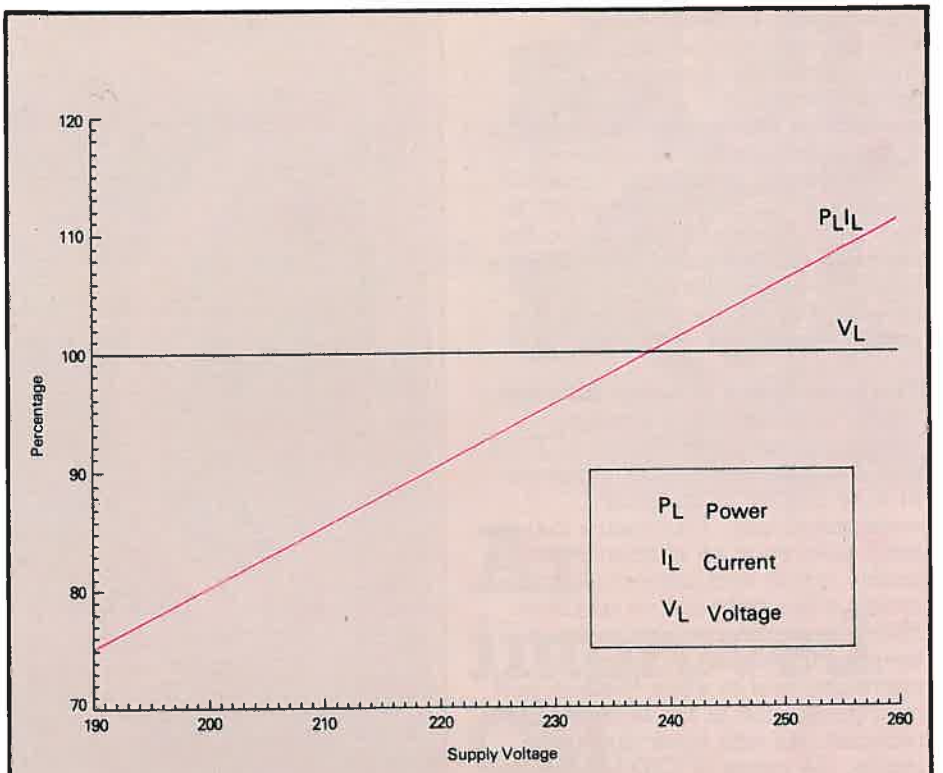


Fig. 1 Dependence of electrical characteristics of lamp on supply voltage.

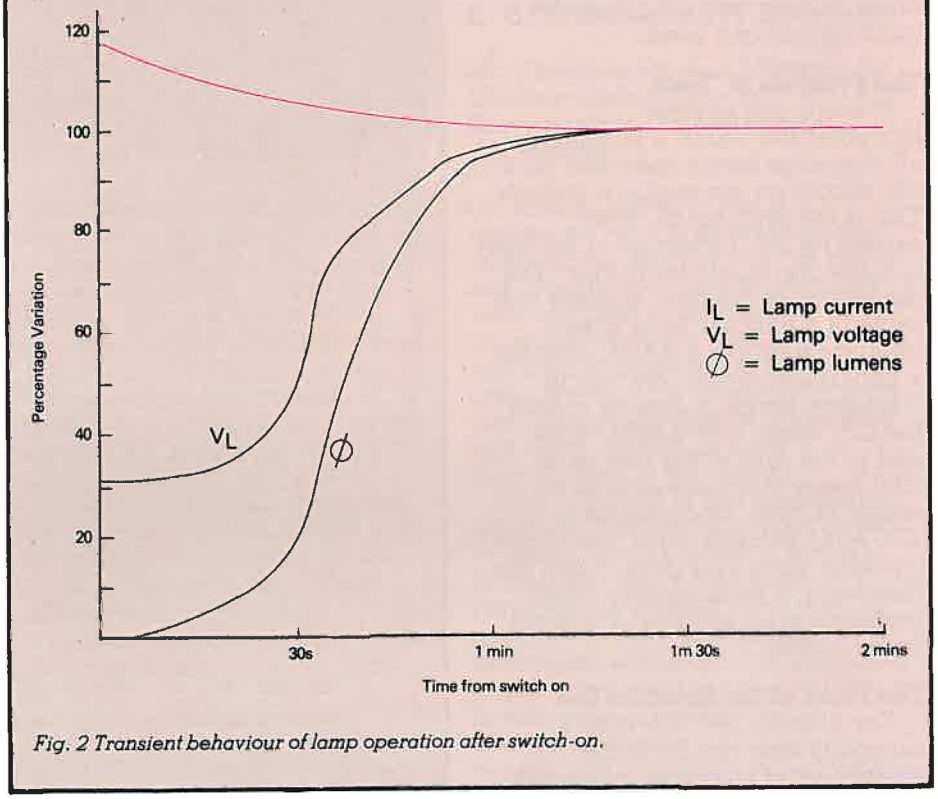


Fig. 2 Transient behaviour of lamp operation after switch-on.

characteristic, which is attributed to the dose being totally evaporated even at the lower wattage value, provides excellent colour stability against variations in supply voltage.

Spectral Distribution

The spectral distribution of the light from a CID lamp is designed to give a correlated colour temperature of 5500K and is shown in fig. 4. The accepted daylight distribution D55, corresponding to a north sky colour temperature of 5500K is also plotted on this graph. It is apparent that although the lamp emission spectrum is more peaky, the curves do have a similar form. The excellent colour rendering properties of the CID lamp is due to the high degree of continuity of its spectrum and this is the result of the tin halide molecular radiation. When evaluated by the CIE method, the general colour rendering index is 85. Both colour and colour rendering properties remain stable throughout life.

Photometric Characteristics

In the table can be seen the photometric characteristics of the sealed beam lamp. By placing the arc tube at the focus of the reflector it has been possible to achieve a peak intensity of 850,000 cd with a beam of 8° to half peak and 20° to one tenth peak intensity. Using the range of four standard PAR 64 glass lenses over the clear glass of the lamp makes a variety of beam angles possible.

The Importance of Lamp Efficacy

The most important property of lighting when shooting film or TV is that it should render the maximum picture quality in the most economical way. This means that the lamp used must be efficient; easy to install, adjust and control and must produce the right colour qualities. High lamp efficacy is important in keeping the electrical load to a minimum, and to allow the size and heat dissipation of the lanterns to be reduced. As with other discharge lamps, the range of CID lamps will give more than twice the light output of filament studio lamps of equivalent wattage and the lamp has a maintenance of light through life characteristic matching that of a tungsten halogen lamp.

The Problem of "Beat"

There is one adverse characteristic which is common to all discharge lamps operating on an AC supply on conventional ballasts. This is the problem of "beat", caused by the fluctuation of the light at twice the supply frequency. The diminution of the light at every half cycle in a filament lamp is very little, for example a 500W lamp has a fluctuation of only 7%, but in discharge lamps it is much greater; the CSI lamps give a 62% ripple and in the case of the rare earth HMI lamps this fluctuation is in excess of 80%. In comparison, the CID lamp exhibits much less ripple, typically 45%. This gives much less likelihood of experiencing "Beat" problems when shooting at normal frame speeds.

The Proof of the Lamp in Use

The ultimate test of a lamp's suitability does not lie in the assessment of its colour properties by the correlated colour temperature and colour rendering index, but rests with the camera man and the results he gets in shooting daylight filmstock. Independent assessment of the CID lamp in comparison with other commercially available lamps has been most encouraging.

One of the novel features of the CID lamp is its ability to vary the intensity over a limited range without any significant change in its colour properties. This not only results in the colour of the light it emits being insensitive to mains voltage fluctuations, but offers the prospect of lamp dimming.

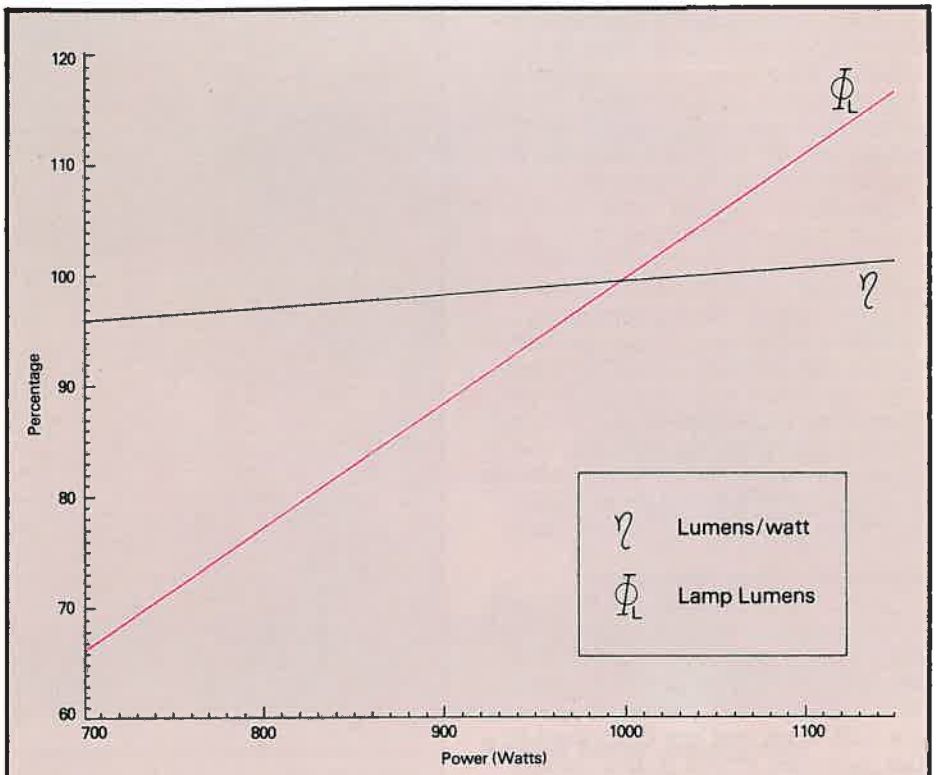


Fig. 3 Dependence of optical characteristics of lamp on power dissipated.

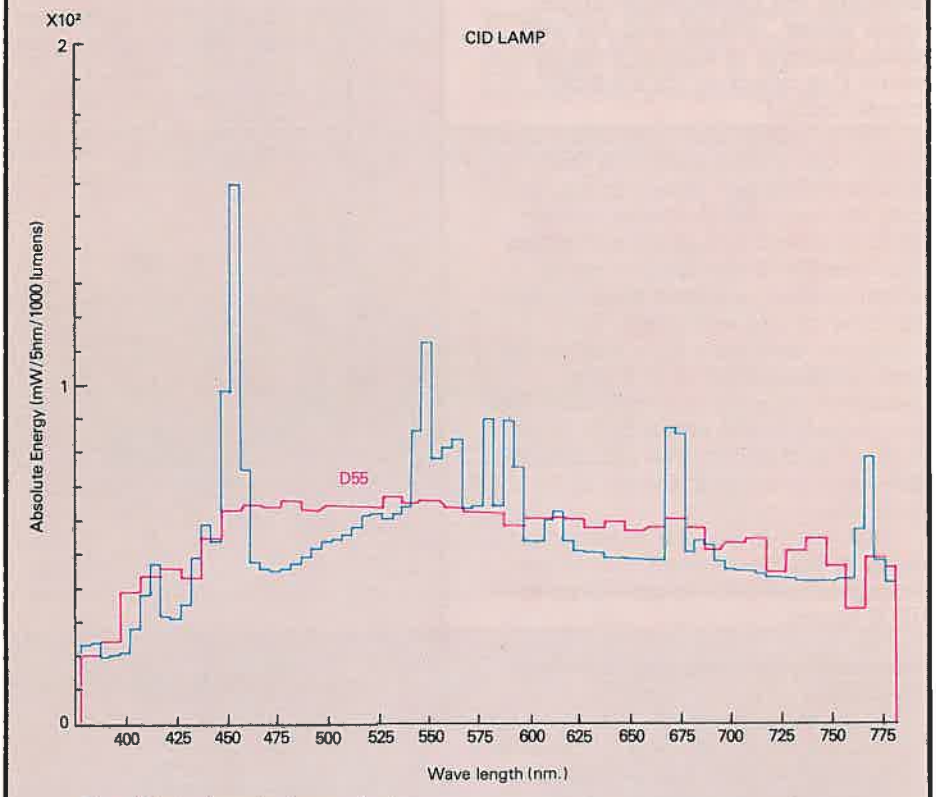


Fig. 4 Typical spectral power hystogram.

Future Trends

The 1kW CID lamp is already in demand for location filming. In particular the PAR 64 sealed beam unit with its high intensity, provides high-lighting effects that compete with the carbon arc. The next rating to be made available will be a 2-2½kW lamp with a lumen output in excess of that of a 5kW tungsten filament lamp.

The hot restrike designs have already increased the convenience of the discharge lamp. Already on the horizon are prototype designs for electronic ballasts which will provide completely flicker-free, dimmable illumination. These ballasts with their associated high efficiency, light weight and flexibility of supply voltage should extend the important convenience factor so essential to location filming.

The improved floodlight housing for the CSI or CID lamp.

An improved CSI floodlight.

D. C. T. Brooks and P. Davenport

Mr. Brooks is Product Manager for Outdoor Lighting and Mr. Davenport for Control Gear & Accessories.

Partially as a result of the introduction of the 1kW sealed-beam hot-restrike lamp, described in the previous article, a floodlight to supersede the OM 1000 was required to retain the features of low windage profile, and to include many additional features.

The 1 kW CSI lamp and OM 1000 floodlight have served us well for almost a decade. The first installations of a CSI floodlighting system were installed during the close season of 1970 for West Ham United football club. Articles appeared in issues 6 and 10 of the "Lighting Journal" on the introduction and early days of CSI floodlighting and issues 13 and 19 described installations of OM 1000 floodlights with 1 kW sealed beam CSI lamps in Iran and the Arabian Gulf, and the use of CSI for outdoor broadcasting purposes.

Design Council Award

The innovative development of the CSI lamp has been recognised by a Design Council award. In fact the compact light source which permitted the development of a small powerful floodlight (the CSI lamp has a peak beam candle power of 1.5 million candelas) represented a major step forward. High illuminance specifications of colour TV transmissions could be achieved, without increased wind loading on towers or suffering penalties on electrical loading. It would perhaps be possible simply to accept the success of CSI, but instead the research and development teams at Leicester and the Fittings Design and Engineering Department at Enfield have continued to improve and develop the products to meet challenging new specifications. A new floodlight has been developed to meet the most arduous conditions of stadia lighting, and to take the new CID lamp described in the previous article to meet the specialised requirements of the film and TV industries.

Assessing the design problem

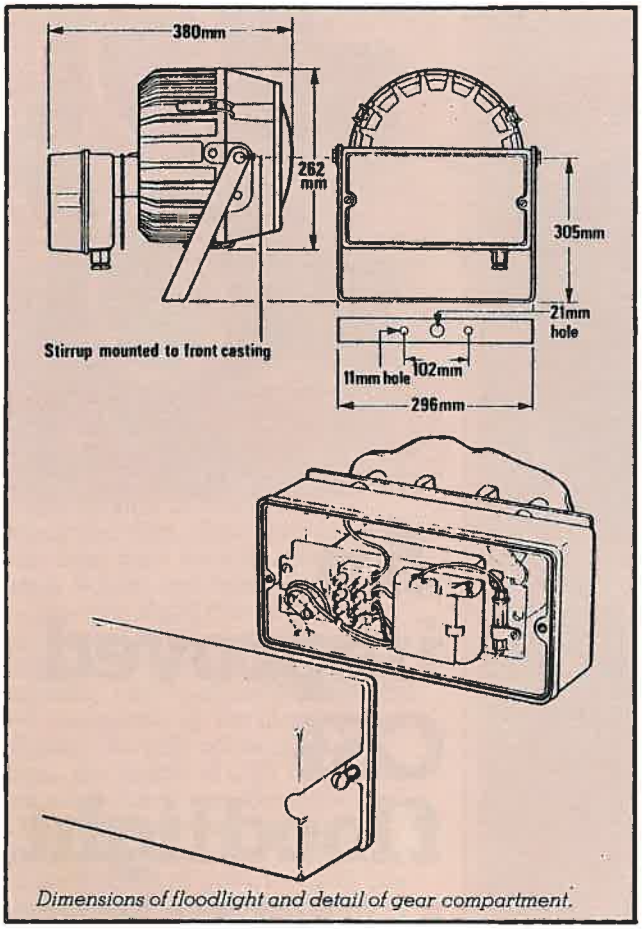
From the outset it was clearly a case for close co-operation between lamp engineers and luminaire designers. Before embarking on this venture, a design team examined several existing floodlighting schemes and visited places where installation work was in progress in order to assess the strengths and weaknesses of the existing product. Electrical contractors were consulted regarding their initial installation experience and the subsequent operational performance of the system. Mounting locations on head frames and stand roofs were examined to permit ease of access for aiming and re-lamping luminaires, and to ensure that the safety of the installer was not put at risk. Preliminary design proposals were matched to problems encountered in the field and modified appropriately. Special considerations for overseas projects such as high ambient temperatures and dusty conditions were incorporated in the design.

With the bulk of market research complete, the task of getting down to design details began. Thermal limitations, safety standards, performance criteria and other parameters were established. Prototypes were built and subjected to extensive testing in the Enfield laboratories. Development of a specialised ignitor necessary to restrike the sealed-beam hot restrike lamp proceeded parallel to the luminaire programme.

The main specifications of the new floodlight are shown overleaf; in fact there are two floodlights using the same basic housing, but with ignitors for standard sealed-beam or hot restrike lamps as appropriate.

The importance of hot restrike

Perhaps the single most important introduction is the hot restrike facility. When in 1970, the first CSI floodlight appeared, the



Dimensions of floodlight and detail of gear compartment.

Specification for OQ 1000 series floodlights

	OQ 1000	OQ 1000HR
1. Lamp type(s)	1kW sealed beam CSI and CID	1kW sealed beam hot re-strike CSI and CID.
2. Control gear	to incorporate ignitor	to incorporate hot re-strike ignitor
	ballast/PFC remote	
3. Mounting	single stirrup or 4-way array	
4. Compliance with standards	BS 4533: 2.5 (IEC 598) BSI Safety-Marked	
5. Environmental and Protection classification	IP 54 Dustproof, splashproof. Class 1 luminaire. Minimum t_a 35°C — outdoor t_a 40°C.	
6. Photometric	Narrow to wide beam spread achieved by use of selection of interchangeable clear and prismatic front glasses.	
7. Principle Mechanical Features	a) Simple lamp insertion and replacement. b) Flexibility to change front glass on site and give positive location of glass without impairing the seal. c) Robust retaining catches to obtain easy access for re-lamping. d) Low windage. e) LM6-M aluminium castings with high temperature paint finish. f) Long service life. g) Facility for re-lamping from rear of luminaire for floodlighting. From front for TV/Studio use.	

requirement for an instant start facility in the event of a voltage dip or failure was negligible. However, in the ensuing years, hot restrike became essential and the OQ 1000 HR fitting was developed to make use of the sealed beam type of both CSI and CID lamps and to meet a growing demand for hot restrike studio floodlighting.

Momentary extinction of supply

In addition to its use in film studios, hot-restrike has advantages in outdoor installations in countries where the power supply is unreliable or has poor regulation and there is an increased risk that the floodlighting will be extinguished either due to power failure or to a momentary interruption in the supply. All standard discharge lamps take time to cool down before any attempt can be made to restart them. With the OQ 1000 HR, the ignitor will restart the lamp automatically, immediately the power is restored.

Where the interruption of the supply is only momentary, hot restrike allows full floodlighting to be maintained in circumstances where standard discharge lamps would remain extinguished for at least ten to twenty minutes. Where there are standby generators, power can be made available and a return to full lighting achieved very quickly, so that activities continue without interruption. Where colour TV is involved, particularly of important international events where TV pictures are a valuable commodity, the protection against loss is an important factor which hot restrike can provide.

Security is also of paramount importance, especially where large crowds are gathered. The continuation of full floodlighting, which often uses spill light for this purpose, is an essential part of overall security for such events, as the sudden and unpredicted loss of light can lead to crowd disturbances, theft and violence.

The effect of the dichroic reflecting surface

As stated in the preceding article a 1 kW CID or CSI lamp requires a pulse voltage of 30 to 35 kV to initiate the immediate hot restriking of the lamp and a special version of the lamp with a dichroic coated reflector is necessary to ensure that adequate creepage and clearance distances are observed. This creates a thermal problem for the luminaire designer, since the infra-red radiation passed through this coating is much in excess of that passed through the aluminised reflecting surface of the standard PAR 64 version of the lamp.

Basic principles of an ignitor

In order to assess the specification for a hot restrike ignitor, one must first consider the "cold" starting of a 1 kW: CID or CSI lamp. Tests have established that a pulse voltage in the order of 9kV applied for a period of up to 7 seconds will establish an arc in the lamp.

The circuit shown in fig. 1 has been successfully used since the introduction of the CSI lamp. Its only limitations are that a manual switch or a delay relay is needed to provide the initial seven second's energisation of the ignitor, and the necessity for manual resetting of the circuit in the event of a voltage dip or failure resulting in the extinction of the lamp. The second, perhaps, presents the potentially greater problem, since it is coupled with the fact that, in common with other metal halide lamps, a CSI or CID lamp, mounted in a luminaire, takes something in the order of 16 minutes to cool down before it will restrike.

Requirements for the ignitor

Beside the requirements for automatic resetting of the ignitor and the high pulse voltages needed, the ignitor must operate on 220/240V 50 or 60 Hz supplies with satisfactory starting, down to 200 volts. It must function reliably in the temperatures experienced in the vicinity of the lamp (i.e. a case temperature of 85°C) and automatically provide a three-second starting pulse to the lamp. This is in fact a tough specification, requiring a compact unit to generate high voltage pulses throughout a range of supply conditions and to operate reliably and automatically in high, localised ambient temperatures. Minimising distance from ignitor to lamp to

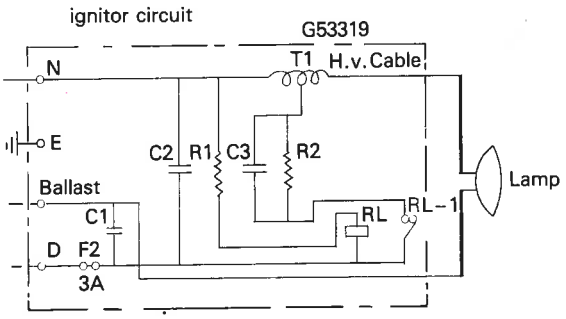


Fig. 1 Standard ignitor

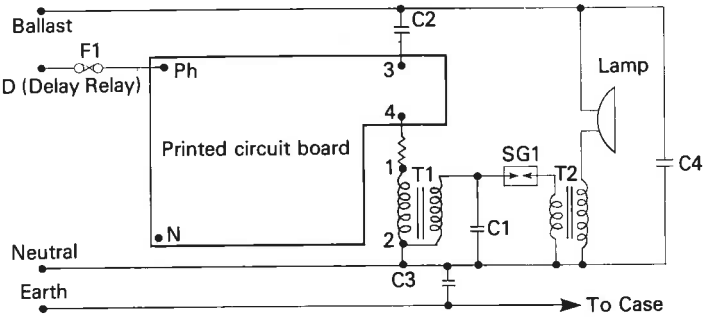


Fig. 2 Hot restrike ignitor

avoid attenuation of the pulse placed a restriction on the arrangement of components and required careful selection of materials to operate at high temperatures. To capitalise on the small size of the lamp, the ignitor, too, had to be a comparably small device. Tests based on a "bread board" design proved the electrical performance before models were built for testing in prototype luminaires.

The operation of the instant start ignitor

The explanation of the diagram (Fig 2) is as follows:

The output from transformer TI is connected to the high voltage capacitor CI. As this capacitor charges, the voltage across the capacitor reaches a value which is high enough to break down the spark gap. When this breakdown occurs the energy in the capacitor is transferred to the primary of the output transformer T2 through the spark gap. The output transformer steps up the voltage, to the level required to start the 1 kW CSI or CID hot restrike lamp, causing a high voltage oscillatory discharge at about 1 to 3 MHz between the lamp electrodes.

The input power to transformer T1 is controlled from the components packaged on the printed circuit board.

When power is available to the system the components on the printed circuit board sense the power and start an electronic timer. The output from this timer operates two relays. One of these relays connects the power to the input of transformer T1 via a triac. This permits the generation of the high voltages required to start the lamp. At the same time a second relay operates and connects an ignition support system (across the lamp), comprising a resistor and a capacitor (C2) mounted near the printed circuit board. The timer continues to operate the relays for 1½ to 2 seconds after the power has been sensed and then the timer resets turning off the relays. This completes the normal starting of the lamp.

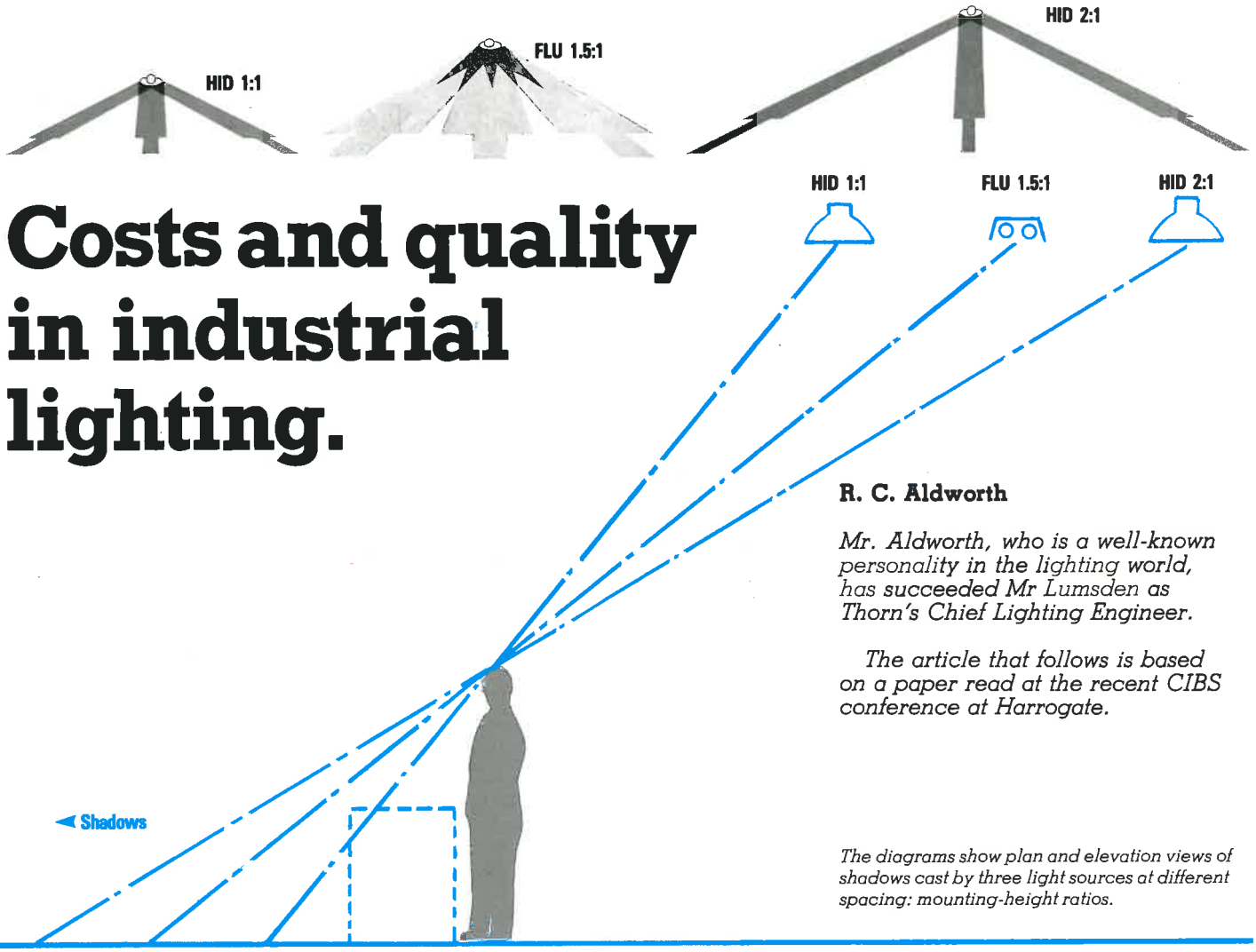
If during the course of operation of the system there is a power failure, the components of the printed circuit board will sense the lack of power and when the power is restored the starter will re-operate and start the lamp automatically.

Helping the customer to make the best use of the floodlights

The finished product not only fully meets the marketing specifications, but complies with the Safety Mark requirements of the British Standards Institution. But the manufacture of the product is not the end of the story. With development work completed and production models leaving the Hereford factory, begins the application of the new floodlight to actual lighting schemes.

Although the new luminaires are the key component of a complete floodlighting installation, the planning of schemes using computer techniques and guidance on installation must all be taken care of, and are regarded as part of the overall package. A data folder to assist in scheme planning together with a full lighting specification is available to order, and can be supplied tailored to suit individual stadia or other installations. Thus it is hoped to ensure that the products are used to the best effect and this is part of the work of the Thorn Lighting Engineering Departments.

Mont Orgeuil Castle, Gorey, in Jersey, formerly floodlighted by four high intensity carbon-arc searchlights is now lighted by 27 CSI floodlights from a distance of 400m. The illuminance has been increased by 250% and the load reduced from 56 to 30kW.



Costs and quality in industrial lighting.

R. C. Aldworth

Mr. Aldworth, who is a well-known personality in the lighting world, has succeeded Mr Lumsden as Thorn's Chief Lighting Engineer.

The article that follows is based on a paper read at the recent CIBS conference at Harrogate.

The diagrams show plan and elevation views of shadows cast by three light sources at different spacing: mounting-height ratios.

The subject of industrial lighting receives scant attention even in periodicals catering for the lighting industry. In the past five years, only five articles devoted to the subject have appeared in the principal lighting journals in the UK which is surprising when it is realised that one third of the nation's work force is employed on the factory floor.

It is probably true to say that most factory workers are called upon to perform more exacting visual tasks in less pleasant environmental conditions than any other group of workers. The work is often physically demanding, repetitive and boring. It is also an inescapable fact that this country depends for its survival upon the success and efficiency of its manufacturing industry.

This apparent lack of interest in industrial lighting is not peculiar to the UK; manufacturing industry is no less important to the economies of the rest of Europe and the USA, but the lighting journals from these countries show a similar dearth of published material.

The provision of quality and effectiveness in industrial lighting cannot but result in improvements in safety, morale and labour relations. These factors in turn could be reflected in improved productivity and this is sufficient justification for giving far more detailed consideration to industrial lighting problems.

It is high time that the overwhelming influence of the accountant and the energy manager was challenged when it comes to the selection of a lighting scheme. Cost and energy saving considerations have led to an increasing use of high efficacy discharge lamps and luminaires in industry, and have also tempted some lighting engineers to stretch the system to a point where the quality and effectiveness of the lighting design is impaired.

Lighting development

When high-bay industrial lighting systems were first devised, some 40 years ago, using tungsten or high pressure mercury lamps, a concentrating reflector was used to give high utilance and acceptable glare control. This meant that the fittings were installed on a 1:1 spacing/mounting height ratio. Little light reached the walls and roof, but as these were usually dark in colour, either by design or the deposit of dirt, there was little point in trying to light them. These installations produced a uniform horizontal illuminance, but the vertical plane illuminance was low and the installations often looked gloomy, because of the 'tunnel effect' caused by the dark walls and roof.

In the '40-s and '50-s fluorescent lamps mounted in trough reflectors with much wider intensity distribution were commonly used. The high efficacy of the lamp justified the cost of installing more lighting points, especially where trunking systems were introduced, and it was possible to throw more light on those dark walls and roof areas, which in spite of their low reflectance, responded to the lumens they received. In fact, industrial areas lit with fluorescent equipment tended to look less gloomy and overpowering, even when the horizontal illuminance had not been increased, because the lighting was uniform and relatively shadow free. This lack of shadow was a major sales feature of fluorescent in its industrial heyday.

Only in installations with mounting heights of 12m or more was the high wattage tungsten lamp and the uncorrected mercury lamp in a concentrating reflector still to be found, but with the introduction of high efficacy colour-corrected mercury lamps, followed by metal halide and high pressure sodium lamps, the merits of high-bay lighting systems have been re-discovered.

The effect of lamp efficacy on fittings design

The higher the wattage of a discharge lamp, the more efficient it becomes in converting energy into light and the lower the proportion of control-gear losses, so that lamps of the highest possible rating should be installed. Using these high lumen packages with the old type of BZ 1 high-bay reflector on a close (1:1) spacing, limits the wattage that can be used to produce a given illuminance on the horizontal plane, and therefore reflectors with a batwing distribution have been developed. These can be spaced further apart, while still achieving adequate glare control and uniformity of illuminance. Wider spacing also reduces installation costs and has provided some excellent installations, but it has two practical disadvantages, first that the failure of one lamp affects a larger area of the factory floor and second, that the smaller the size and number of the light sources, the harder are the shadows on the work-surfaces.

The effect of shadows

The commonest form of obstruction to light falling on the working plane is the worker himself. A person standing midway between two rows of luminaires will not only cast shadows on the floor, but also on the horizontal surface of the work bench and upon possibly more important vertical surfaces in front of him.

The worker's body is not the only cause of obstruction. For example, the shadow of a drill-stand on the task area may be quite heavy, and on assembly lines the presence of conveyors and component storage racks can cause serious obstructions. Although high pressure discharge lighting systems present a greater problem in this respect, it is not true to claim that fluorescent systems are entirely shadow-free, particularly where the object causing the obstruction is parallel to the line of the luminaires.

Some practical comparisons

Consider a 30m x 60m industrial area with a mounting height of 5m and a 30% wall and ceiling reflectance, lighted with

a) High Intensity Discharge (HID) lamps in BZ 1 reflectance spaced at 1:1
b) Higher wattage HID lamps in batwing reflectors spaced at 2:1
c) Fluorescent reflector fittings spaced at 1.5:1.

All three systems can be designed to give the same horizontal illuminance, but the quality of lighting provided by each is significantly different. Comparing the proportion of cylindrical (average vertical) illuminance to horizontal plane illuminance, in the table overleaf the 1:1 HID installation gives 18% whereas in the 2:1 spaced installation it is 31% of the horizontal value. This is similar to the 33% given by the fluorescent system, but an important difference is in the type of shadows cast by the different luminaires. The plan view of the shadows cast by the worker's body from 3 HID fittings spaced at 1:1 is shown on the facing page. At 2:1 spacing, the shadow length is increased and is more likely to obstruct illuminance on vertical surfaces, while the fluorescent system at the intermediate spacing of 1.5:1, produces another type of shadow pattern and because of the linear form of the lamp, the shadows are less distinct.

When one considers the direct

In the welding shop of Barry, Henry and Cook of Aberdeen an acoustic ceiling provides sound insulation for offices above. Lopak fittings housing 400W SON lamps are recessed in it, to allow clearance for the travelling gantry crane. Using SON lamps instead of MBF reduced the number needed from 46 to 42 and the load from 12 to 7.8 kW.

obstruction loss to the horizontal illuminance at the task position, the 1:1 and 2:1 HID installations give losses of more than 40%. In the case of the fluorescent system, the loss is only 24%. Of course, inter-reflected light reduces these losses and the effects will vary due to different conditions at each task position, but the average value of 8% inter-reflected illuminance would be achieved for both HID schemes. This will be increased to 12% for the fluorescent scheme, giving even lower obstruction losses for this system.

SPACING AND TYPE	MEAN Ev/Eh	MEAN Er/Eh	OBSTRUCTION LOSSES	
			DIRECT	DIRECT + INTER REFLECT
HID 1:1	0.18	0.08	41%	38%
HID 2:1	0.31	0.08	45%	42%
FLUORESCENT 1.5:1 TRANSVERSE 1:1 AXIAL	0.33	0.12	24%	21%

Localised lighting

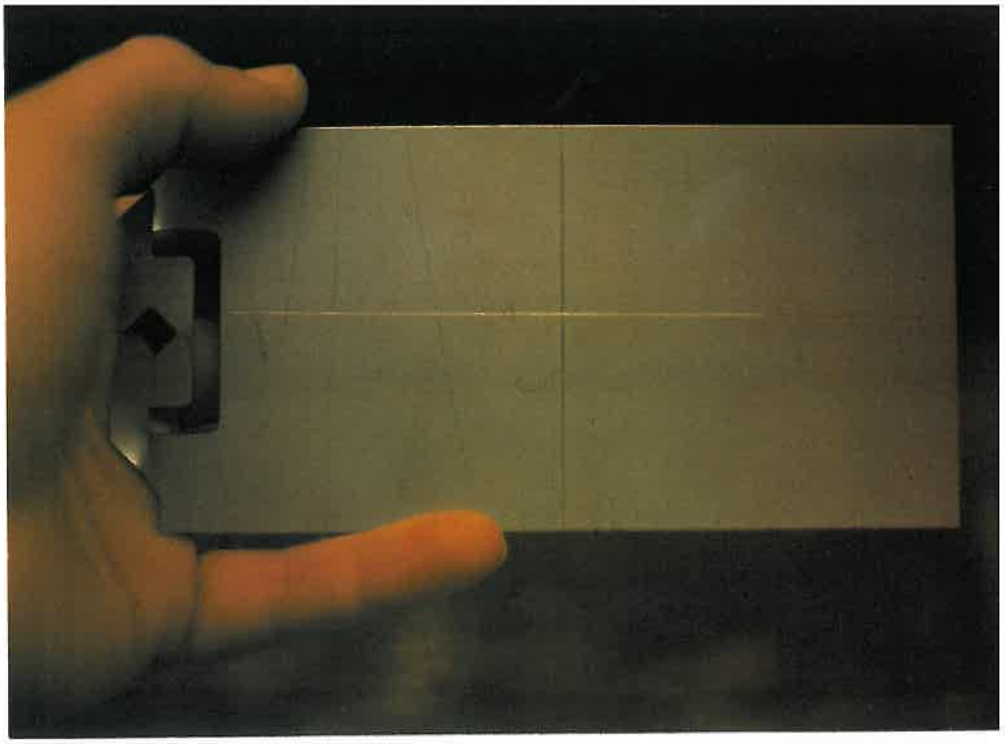
If shadows, however caused, are overcome by the use of local lighting without reducing the value of the general lighting, the overall running costs of the installation will be increased, but it is a mistake to assume that local lighting alone can ever be adequate. Apart from considerations of glare and the need to light gangways and service areas, it encourages the accumulation of rubbish under benches and produces heavy shadows which may be a source of danger. It is, however, not uncommon for a general lighting scheme to be installed on the basis of low cost and energy saving only to find that local lighting has subsequently to be added to overcome shadow problems which tends to negate the economic merit of the original scheme.

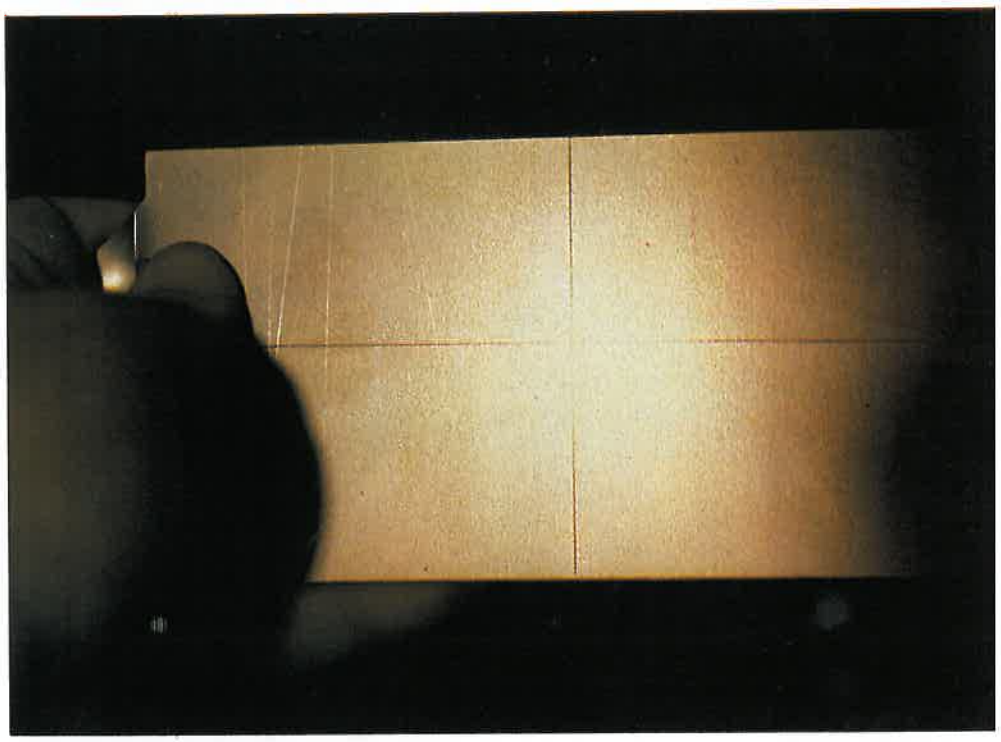
The use of directional lighting

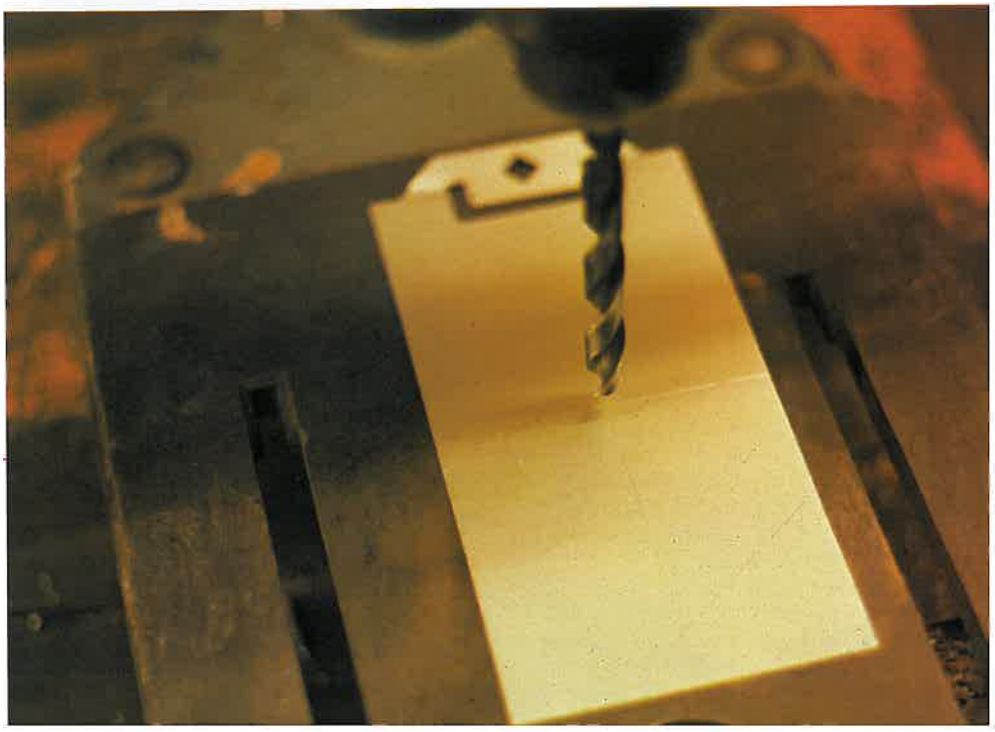
It must be stressed that for some visual tasks, shadow-free lighting

Below may be seen the new lighting installed in the test area for the new IBM Display System at Greenock, Scotland. Thorn Lopak fittings, housing 250W metal halide lamps, are mounted in pairs above the benches in specially made boxes with diffusing panels. They are supplemented by a single row of Lopaks above each gangway. An illuminance of 600 lux on the benches and 400 lux in the gangways was achieved with a 42% saving in current compared to the original general lighting from fluorescent fittings. The 'batwing' distribution of the Lopak fittings provided a high proportion of vertical illumination and improved seeing conditions.

Opposite may be seen how a scribed line on polished metal is easily discerned in a well diffused light, but too concentrated a light-source may produce a glare problem. The bottom picture shows the heavy shadow which may be cast by a drill stand.







does not assist vision. Fluorescent lighting is not a universal panacea for all industrial tasks, the revealing power of directional lighting with well defined shadows is well known and the light source and luminaire must be chosen first and foremost to suit the visual tasks to be performed under their light. For example, detail on a shiny surface, as in a scribed line on metal, is usually seen more easily when it shows up as a dark line against a bright surface which reflects an image of the luminaire, or when the scribed line produces brighter specular reflections than the surface. Both conditions rely on the luminance of the light source reflected in the task and not on the illuminance on it; they depend entirely upon the relative positions of the light source, the eye and the orientation of the surface.

Where powerful widely spaced luminaires are used, the chance of seeing such an image is reduced, and indeed, even where it can be seen, the high luminance of such a light source may make the surface too bright, resulting in reflected glare or dazzle. Consequently for this type of visual task, which is fairly common in industry, a fluorescent lighting system is usually more effective.

The proof of the pudding . . .

Although we must never forget the importance of cost effectiveness and energy saving, a lighting system chosen on the basis of these factors alone will not necessarily provide the correct lighting. If the installation does not aid vision, then it cannot be claimed to be either cost or energy effective.

In many cases, of course, the lighting engineer will be arguing in favour of a high pressure discharge system, not because it is "in vogue" but because it provides the best seeing conditions. Where his knowledge and experience tell him this is not the case, he must argue for an alternative system giving the correct lighting solution even if it uses slightly more energy.

It is then up to him to put his case as effectively as the accountant and the energy manager if the final decision is not to be too heavily biassed in favour of savings in installation and running costs, for the lighting may easily prove uneconomical in the long run because of spoilage or slowing down of production due to poor lighting conditions.

Two important industrial installations

Thorn SON TD lamps are in evidence in two important installations.

At Hamburg docks, shown opposite, a hundred and fifty floodlights are mounted on 3m columns on the roofs of the warehouses and on 18m columns elsewhere. The average illuminance at working level is 50 lux, and the installation replaces a former one using metal halide lamps which provided insufficient illumination.

The low energy costs of the SON lamps combined with much improved lighting conditions have much impressed the harbour authorities and the scheme will shortly be extended.

At Stavenger Fiord, in Norway, a gigantic floating platform is in course of construction. The building of this platform, illustrated above, is the largest project ever attempted in Norway. Its estimated cost is about ten million Kroner, (a million pounds).

The area of the platform is 18,000 square metres and the total height of the concrete construction will be 178m. The structure consists of 24 cells and four shafts standing on 98 steel skirts. The height of the cells will be about 77m, and on top of the shafts will be a deck weighing 25 tonnes, 30m above the cells. The total weight of concrete will be 360,000 tonnes. Work is proceeding day and night, and during the hours of darkness light is provided by banks of Thorn SON TD lamps mounted on the jibs of the cranes. The use of the cranes eliminates the need for any lighting columns which might obstruct the work. There are six cranes, each about 60m high, with a range of 60m. Twenty-five, 400W Thorn SON.TD lamps in OHS 1500/400 floodlights are installed on the jib of each crane and, in addition, a very large number of Thorn Haline fittings housing tungsten halogen lamps are used all over the platform and in the surrounding area.

The platform is being built by Norwegian contractors and is expected to be completed in 1981, when a second one will be commenced.

Operating the project is Mobil Oil (Norway). Statoil, the Norwegian state owned company has a major interest in it. Thorn sold the equipment to the contractors through the Teknisk Bureau A/S in Stavenger.

X-rays in lighting research.

P. J. Clewer

Everyone must be familiar with the use of X-rays in medicine for the internal examination of the human body; these pictures, taken on X-ray sensitive film, are properly called "Medical Radiographs". X-rays also play a very important role in Industry, not only for producing "Industrial Radiographs" of objects with suspected internal defects, but also in two important methods of analysis, known as X-ray diffraction (XRD) and X-ray fluorescence (XRF). While radiography is used to reveal hidden details of a size visible to the eye, or through a low-power microscope, XRD indicates the way in which the atoms are arranged within a substance, and provides a "finger print" for identification of chemical compounds etc., whilst XRF identifies and very accurately measures the relative amounts of chemical elements in a sample, regardless of how they are bonded together. At the Jules Thorn Lighting Laboratories, Enfield, all three of these X-ray techniques are used in research and development on new products, and for quality control on existing items of lighting equipment.

The XRF X-ray apparatus in use in the Jules Thorn Lighting Laboratory at Enfield.

Radiography

The traditional use of industrial radiography is the examination of metal castings and welded joints etc., for defects such as "blow-holes" and internal cracks. Castings for parts of lamp-making plant which require extensive machining are examined for defects before the shaping operations are commenced, thus saving possible wasted man-hours of work in cases where a hidden defect would ruin the final product. Increasing use is now being made of radiography for the examination of lamps and other lighting components. For instance, it is possible to examine the cathodes of a discharge lamp during its operational life, even if the outer envelope is coated with a phosphor powder. High definition radiography will reveal any hidden deformation etc. of the cathode as and when it occurs during the operation of experimental lamps. All GLS lamps and some tungsten-halogen lamps have integral fuses incorporated in the lamp base, the integrity and positioning of which can also be checked by X-rays. Another use is found in the checking of control equipment which is often "potted" in an organic resin, within a metal outer case, to protect the components from the environment. X-rays will penetrate the case and potting medium to show the internal arrangement of the components and their electrical connections.

X-ray Diffraction (XRD)

The atoms in a substance are about a million times too small to be visible in a radiograph. However, they are capable of scattering X-rays just as particles of dust suspended in a light beam scatter the light in all directions and appear as bright points of light. Because the atoms in a solid are always arranged in a very regular pattern, this scattering process from each atom combines to produce a diffraction effect. Thus if a finely collimated beam of X-rays falls on a substance, a series of weak X-ray beams emerge from the solid at various angles to the primary beam, and their position and intensity may be recorded using either X-ray film or an electronic detector coupled to a chart recorder. The resulting pattern is called a "diffractogram", and, since no two substances have the same diffraction, pattern, it can be regarded as the "finger-print" of the substance that produced it. Some patents on the composition and formulation of lamp phosphors are based mainly on this unique method of using XRD data to identify the claimed phosphor compositions and such data is accepted by Patent Offices throughout the world.

A New Technique

For over thirty years, the Thorn Lighting Laboratories have used XRD for the identification of new materials in quality control of existing products and to assist their research and development programme, especially in phosphor research. Recently, the original photographic type of equipment has been supplemented by a diffractometer using the latest electronic methods of X-ray detection and recording, leading to improved sensitivity od detection, and more accurate quantitative results. Although the older photographic technique is by no means obsolescent, and is still preferred for the identification of particles often too small to be visible by eye, which is an important aspect of quality control analysis, the new diffractometer is superior for accurate quantitative measurements on mixtures of chemicals, where the overlapping diffraction patterns of the components must be separated, and the intensities of the individual X-ray beams accurately measured to give a quantitative analysis. One of the special uses of this instrument will be for analysis in connection with the new "Health and Safety at Work Act" to ensure that the levels of toxic chemicals are kept well below the recommended safety limits.

Problems with Plastics

XRD relies on the regular arrangement of the atoms in the sample being analysed; it is not generally known that the double helix structure of DNA was discovered by XRD. Although this is the case for all metals and the majority of other substances, including inorganic chemicals and those of organic origin, there are two classes of materials in which the atoms are arranged in a random way and therefore do not show X-ray diffraction effects. These are plastics and glasses, but although XRD analysis is not possible on these classes of materials, it is possible to determine the individual elements present not only in these amorphous materials but also in most solid and liquid substances by the third X-ray analytical technique, namely X-ray fluorescence.

X-ray Fluorescence (XRF)

Today, most people are familiar with the concept of an atom consisting of a nucleus with electrons orbiting around it. When the electrons in the outer orbits of an element are excited, by, say, an electric arc, or in a low pressure gas discharge, visible light or ultra violet radiation is emitted as in the familiar mercury and sodium discharge lamps. The elements may be analysed by passing this emitted radiation through a spectrograph and measuring the wavelength of the emitted lines.

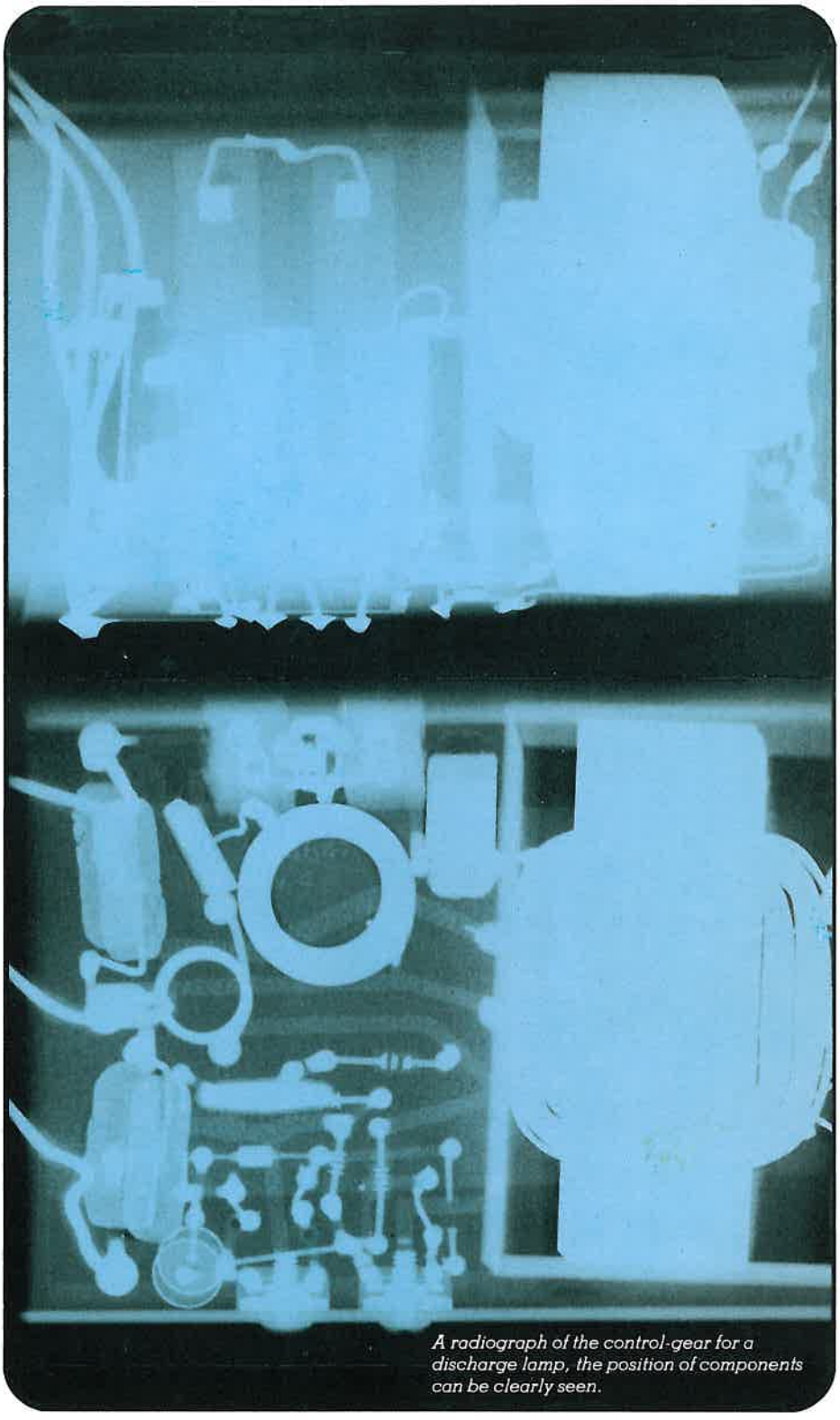
This is the well-known technique of Optical Spectroscopy, but it suffers from two basic limitations, namely the very large number of emitted spectral lines from some elements, which causes line overlaps and difficulties in identifying all the elements and secondly the limiting of the ultimate quantitative accuracy attainable due to the instability of the exciting arc.

Identification of Elements

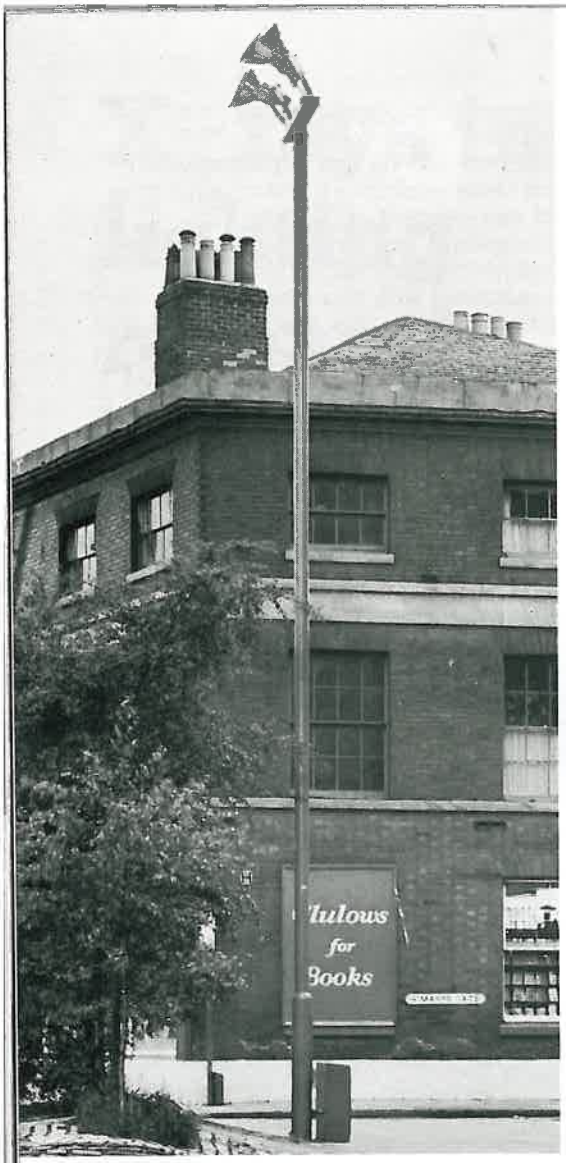
X-ray fluorescence spectroscopy is similar in principle to the optical type, except that the innermost electrons nearest to the atomic nucleus are excited, and the resultant emission is now in the X-ray region of the electromagnetic spectrum. Once again, elements can be identified by measuring the wavelength of this emitted radiation, and the X-ray intensity is a measure of the amount of a particular element present. Excitation of these innermost electrons, lying in the inner electronic shells, requires a high level of energy and is achieved by bombarding the sample with high energy X-rays from a suitable X-ray tube. The atoms of the sample then "fluoresce" and emit the lower energy monochromatic X-rays, the wavelengths of which are measured in an X-ray spectrometer, thus identifying the elements present. The excitation process is much more consistent than in optical spectroscopy, leading to quantitative results of high accuracy.

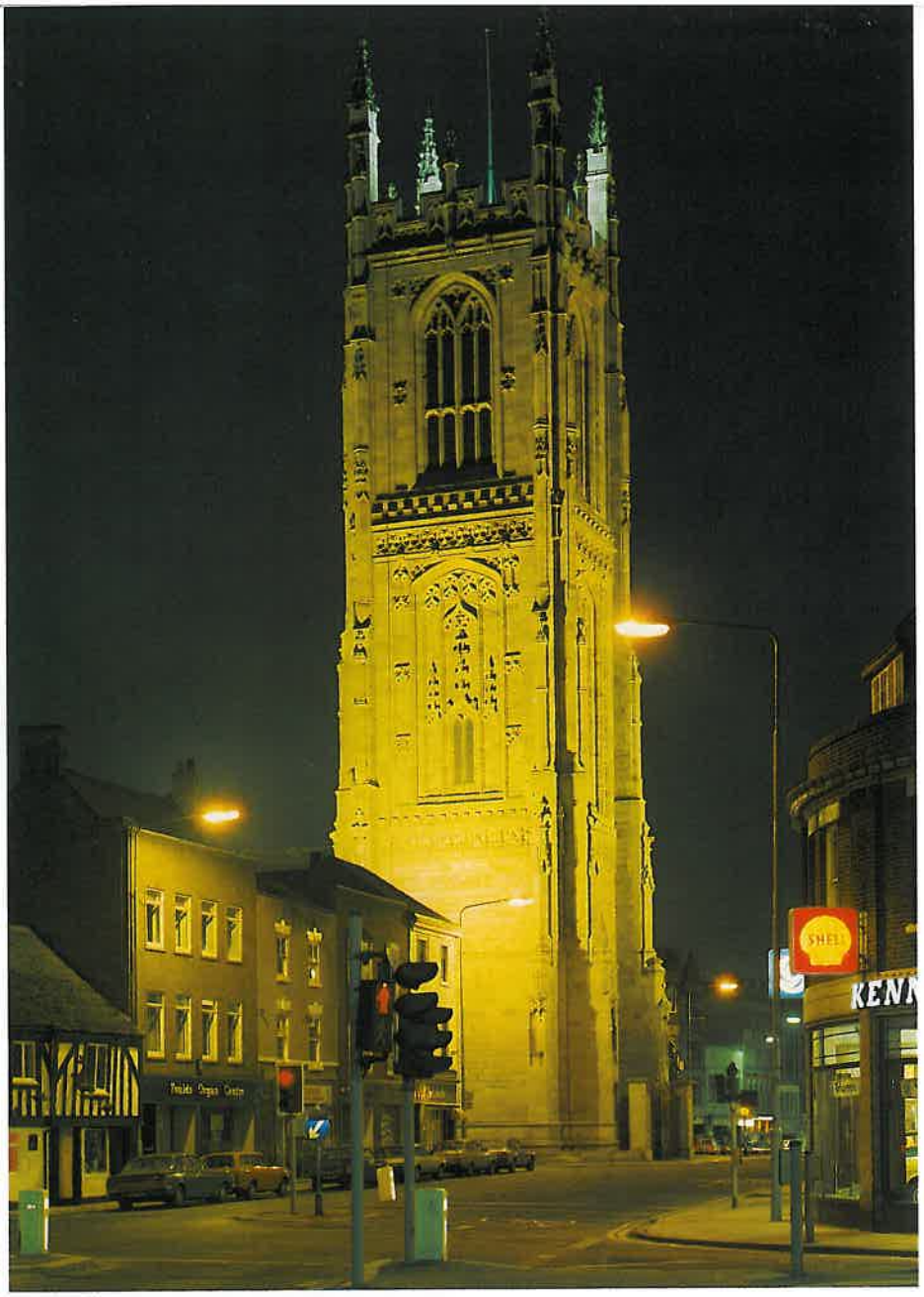
A Versatile System

XRF analysis is very versatile in that virtually all solids and liquids can be analysed for all but the very lightest elements, below fluorine in the periodic table. For example, the rare earth elements are essential constituents of the new high efficacy phosphors, used in our new "Polylux" range of fluorescent tubes. This family of elements is extremely difficult to analyse by conventional methods, but using XRF techniques, rapid quantitative analysis can be accomplished even on trace additions forming a fraction of one percent of the total phosphors, but nevertheless vital to achieving the high efficacy associated with this class of phosphors. By this new technique, many analyses which would have taken hours or days by traditional methods can now be achieved in minutes allowing almost instant quality control of on-line processes, as well as routine spot analysis, and the solving of major analytical problems connected with long-term research.

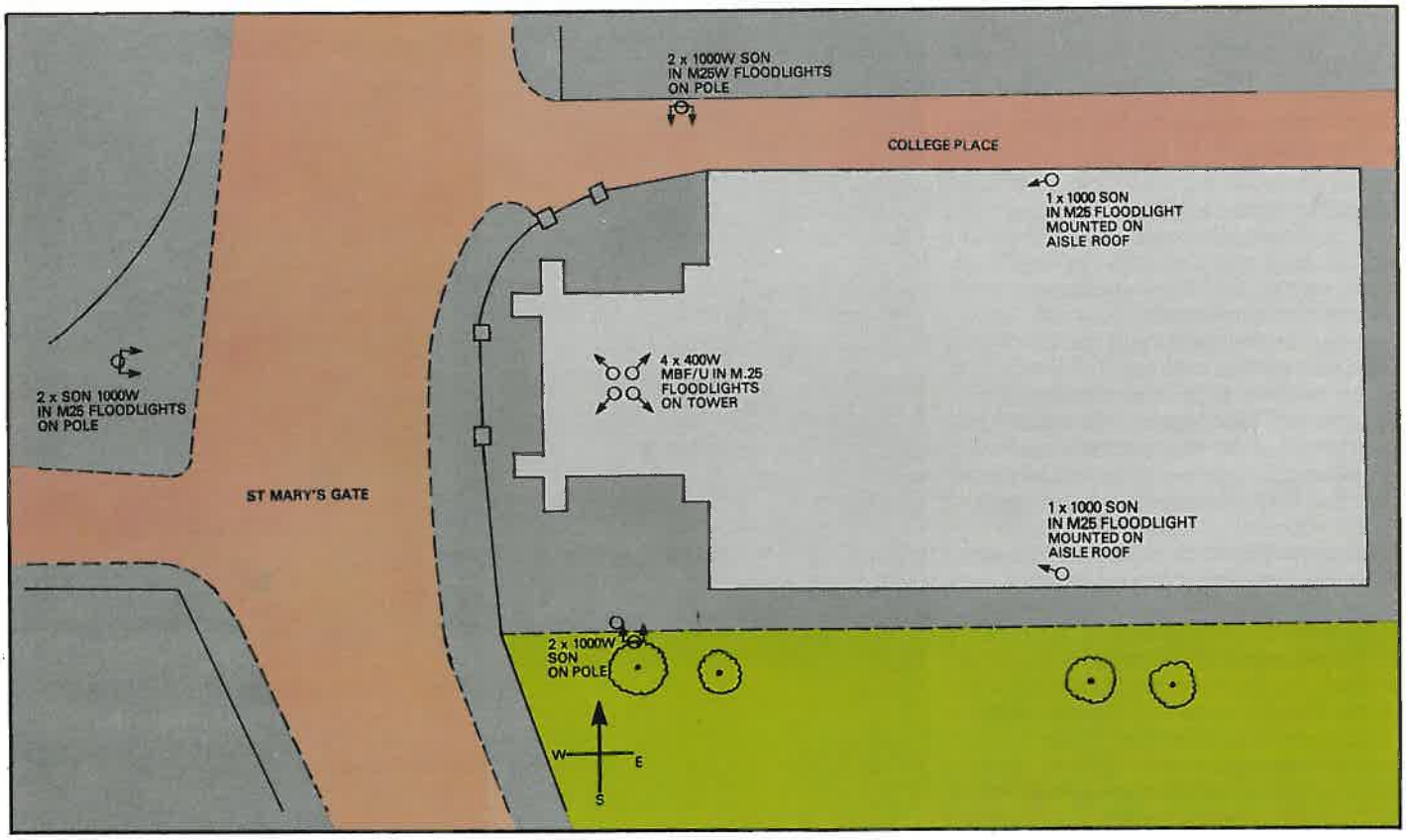


A radiograph of the control-gear for a discharge lamp, the position of components can be clearly seen.





The tower of Derby Cathedral seen from the Northwest; one of the floodlighting poles can be seen in the black and white picture, while the plan, below, shows the disposition of the floodlights. Opposite is the cracking tower of the BP refinery at Grangemouth.



Two unusual floodlighting installations.

The functions of the two towers illustrated on these pages are almost as different as they can possibly be. One is the medieval tower of Derby Cathedral, the other a 'cracking tower' at the BP refinery at Grangemouth, near Edinburgh. Both, however, have unusual lighting techniques which is the reason they appear in *Lighting Journal.*

The tower of Derby cathedral stands at the West end of the building, literally on the pavement of the main street, and it appeared that the only places on which floodlights could be mounted was on buildings opposite it. Placing the floodlights at street level was obviously out of the question, but the other method raised difficulties of access, angles of illumination and so on.

The problem was solved by Derby Street Lighting Department which provided three 10m street lighting poles, with brackets to support the floodlights with control gear boxes at their bases, at the appropriate positions shown on the plan. The main floodlighting is achieved by 1000W SON lamps in M25 Senior floodlights mounted on these poles and on the aisle roofs of the cathedral. Four 400W MBF lamps in M25 Juniors are mounted on the roof of the tower to pick out the pinnacles in a contrasting colour.

The scheme is very successful and the tower is visible from a considerable distance at night, and the finishing touch was given when Derby Street Lighting Department replaced the MBF lamps in the Thorn street lighting lanterns near the cathedral with SON lamps to tie in with the floodlighting.

The Grangemouth cracking tower is also lighted by SON lamps, but in this case they are mounted in Thorn Marine floodlights. They are positioned 50m up near the top of the tower, casting their light downwards to illuminate the access platforms on the tower face. By this means a multiplicity of corrosion-proof fluorescent fittings was eliminated, and the wiring and installation much simplified.

The Distillation Area, Electrical Engineer, who supervised the design and installation of the floodlights, reports that a further advantage of their use is that they not only light the platforms on the tower, but improve the lighting over a wide area at ground level. Most floodlights designed for use in group 2 areas are too dispersive for this type of application, but the DHA 800 type, housing two 400W SON lamps in an accurately profiled parabolic reflector provides both the beam distribution and the power required.

Safety from fire.

J. E. Greenhill and C. T. Hambleton

Mr. Greenhill is Manager of the Thorn Test House at Enfield and Mr. Hambleton Product Manager for Special Luminairies at Thorn House.

With the introduction of the Safety Mark and the expected increase in the demand for 'safe' luminaires, it is only natural that manufacturers should turn their attention to fire safety and to the various regulations and international specifications designed to reduce the risk of fire.

This article is intended to give the user and specifier an insight into how this legislation affects the design of luminaires. It is well known that the Safety Mark only applies to safety and is not concerned with performance; however, as will be seen from the following notes, legislation applies stringent tests when plastics are being used which could ultimately affect the performance of the apparatus of which it forms part.

The effect that international specifications, in particular IEC Publication 598, could have on the design of a luminaire is considerable. This publication will be adopted as the second edition of BS 4533 and will be the basis for the decision as to whether the luminaire could be considered "safe" and be awarded a BSI Safety Mark.

Apart from the Building Regulations and the GLC Code of Practice, there is little published in the United Kingdom to guide the prospective installer. Points discussed are not necessarily covered by these regulations and some commonsense solutions based on the authors' experience of actual situations are put forward.

Guides to installation procedure

Before luminaires can be installed in a building, some basic considerations should be met. For example, plastic materials which can contribute to or cause a fire hazard should not be used. Unfortunately fire-proof plastics materials are usually opaque and therefore unsuitable for lighting purposes. They are required to conform to BS 476 Part 7 1971, Classes 1, 2 and 3, as specified in the Building Regulations. Exceptions to this rule are allowed by the use of type 2 materials, generally acrylics and some polystyrenes. These comply with BS 2782, 1970, methods 102C and 508A and BS 2782 1970 P5 method 508D for the GLC (Greater London Council) Code of Practice.

The Gas Flame Test described on page 22.

Restrictions on use of plastics

Naturally there are restrictions for the use of such materials. For example, the aggregate area of the plastics material used must not exceed between 30% and 50% of the total floor area or circulation space. Additionally the nominal thickness of each panel must not exceed 3 mm and they must be spaced at least 575 mm from one another. Restrictions are also put on the maximum size of panel, but most lighting panels fall within these limits. Coupled with this, all panels must be loosely mounted so that, when softened by heat, they will fall from the ceiling and so minimise the possibility of contributing to a fire hazard.

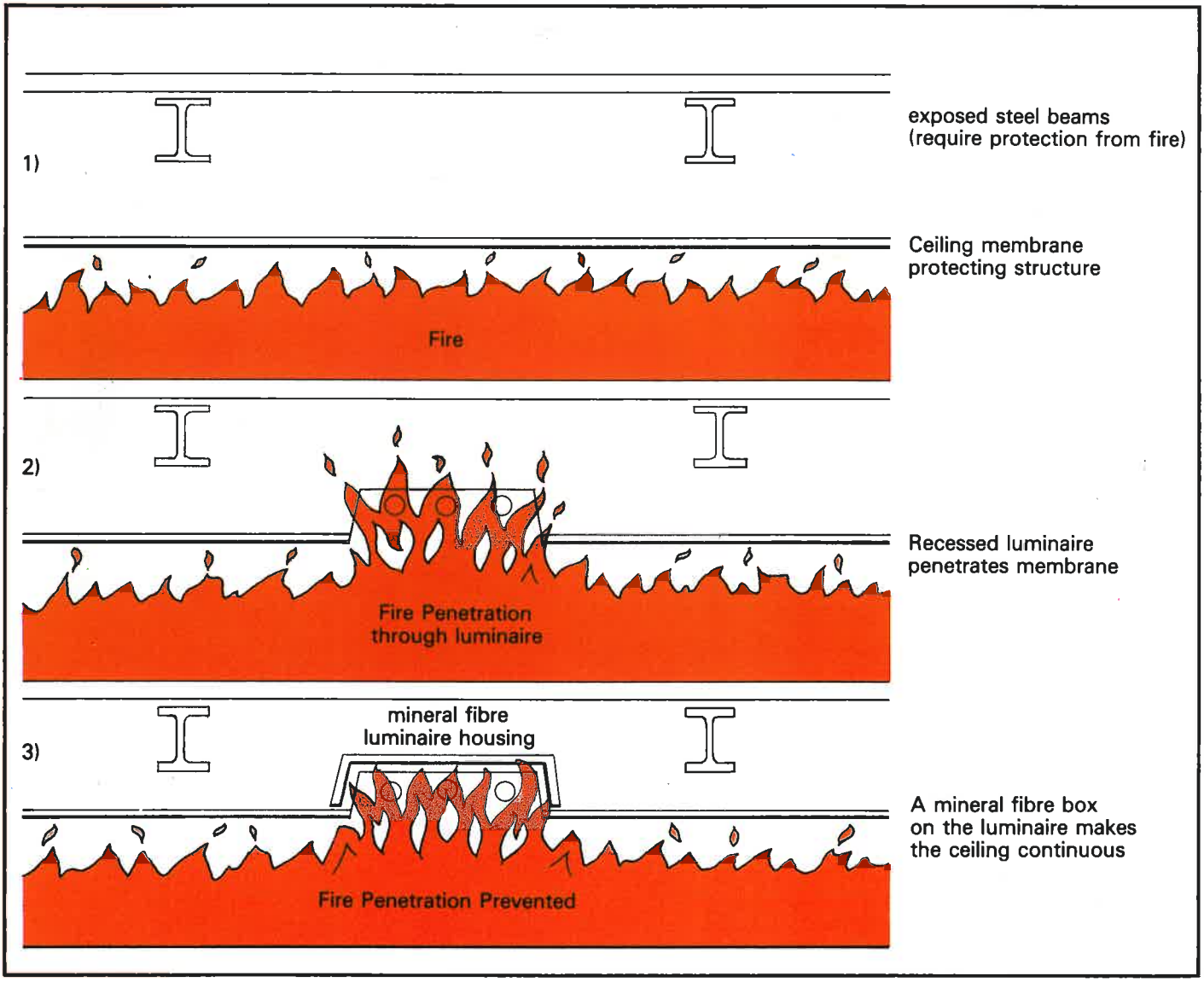
Shielding internal components of air-handling luminaires

In addition to the above, although it is not mentioned in the Code of Practice, the Greater London Council requires that the internal components of air-handling luminaires shall not be directly in the air path. It therefore becomes necessary to ensure that these components are suitably shielded; usually by the use of a plate covering the control gear and its components. In areas outside the GLC control, luminaires of this type are usually designed so that internal components are placed in such positions that exhaust air is unlikely to pass directly over them.

The reasoning behind these restrictions is clearly to reduce the risk of fire starting in a particular area spreading through the exhaust air handling system. It is internationally recognised that these are such commonsense reasons that an additional part to IEC 598 has been compiled to lay down requirements based on them.

Fire rated ceilings

Another important consideration is to avoid disturbing the integrity of a fire-rated ceiling. The aim of this type of ceiling is to protect certain types of structure, principally timber and steel constructions, against fire damage. However, it is worth noting that modern buildings constructed in reinforced concrete have built-in fire resistance and therefore do not require a fire-rated ceiling.



Fire rated ceilings are generally of the mineral fibre type that can provide 1 hour resistance (concealed fix) or half an hour resistance (lay-in). Luminaires used in such ceilings can be boxed in to ensure that the ceiling membrane, though no longer flat, remains impenetrable to fire. The diffuser or controller, although not affecting the fire rating, must normally comply with BS 2782, but it must be remembered that no recessed luminaire can be fire-rated by itself. It can only be considered in conjunction with a ceiling.

Areas covered by regulations

These documents are quite specific in their requirements but they only cover England and the GLC area. However, the regulations are based on practical commonsense which will normally prevail in those areas where regulations do not exist.

It can be seen that the clear intention is to restrict the amount of flammable material used in or on the ceiling and the Building Regulations and the Code of Practice published by the GLC insists on plastics materials complying with BS 2782 and being restricted as a percentage of the floor area. If in doubt the local fire officer will assist where a specific building is involved.

Testing procedures for luminaires

The new International Standard IEC Publication 598 covers safety requirements of most types of luminaire and this standard will become the harmonised specification for all European countries including the UK where it will replace the present BS 4533 as a second edition.

Part 1 Section 13 of IEC 598 includes requirements and tests relating to "Resistance to Fire" and it is important to understand how these International fire tests for luminaires came about.

Most earlier luminaire specifications e.g. IEC 162, and in the UK, BS 3820 and BS 4533 had only a general requirement that certain parts of a luminaire shall be "self-extinguishing" but there was no test by which this important requirement could be judged. An exception is CEE 25 which has a fire test using the "hot mandrel" apparatus, but this relates only to insulation retaining live parts in position and is only appropriate to domestic type filament lamp luminaires.

A special international committee

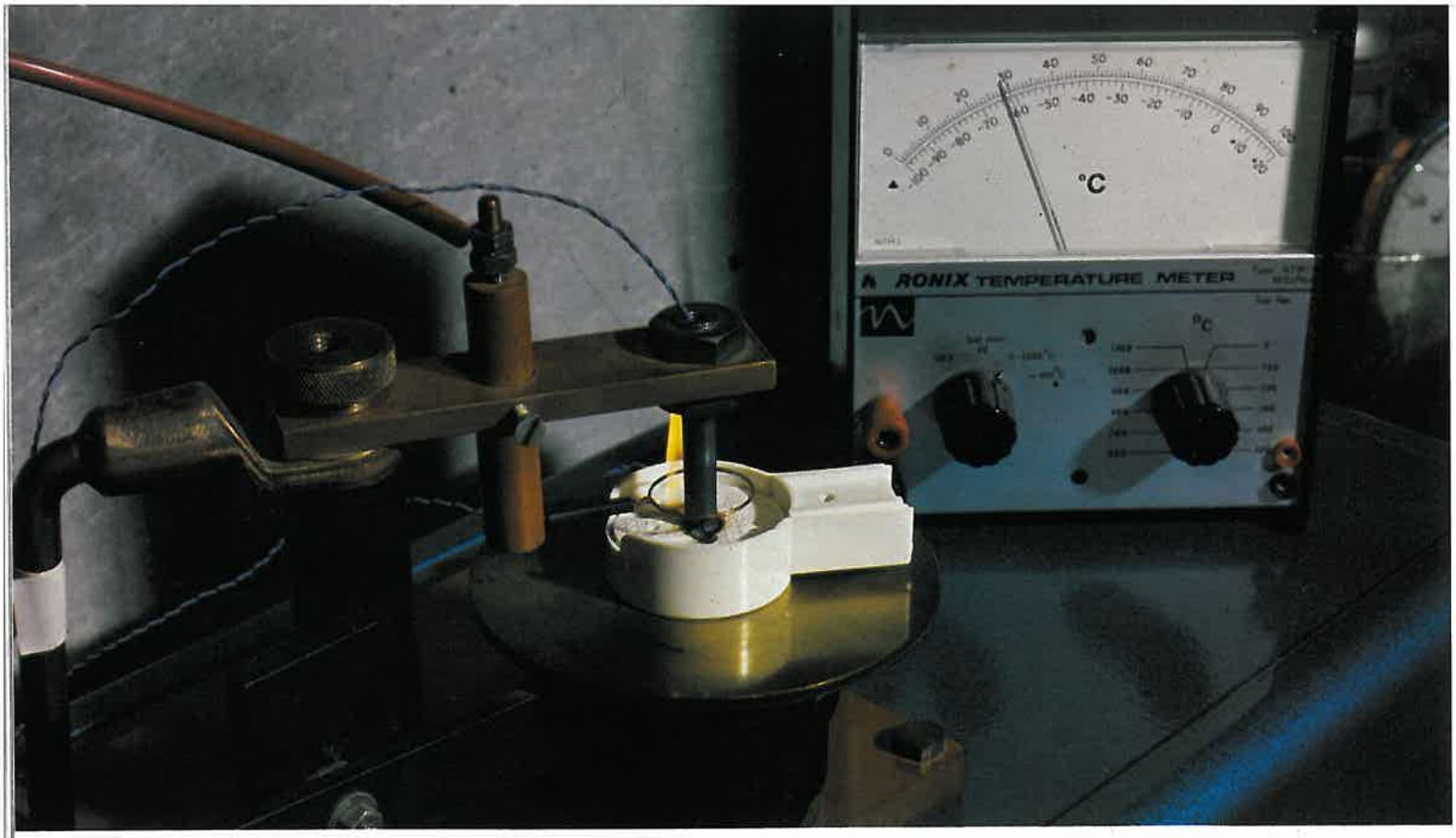
This was a most unsatisfactory state of affairs which encouraged the various test houses throughout the world to apply their own interpretations and tests.

The reason for this gap in the luminaire specifications is that discussions have been going on in a specialist international committee for some twenty years or so with the aim of getting agreement for fire tests which could be used for all kinds of electrical equipment.

Some specific tests

One of the tests evolved by this committee uses the "glow'wire" apparatus where a hairpin shaped wire is heated to 960°C, the melting point of silver. It is intended as a pre-selection test for insulating material, but unfortunately this test is somewhat unrealistic because it rejects most thermo-plastic materials, many of which have been shown by long experience to be quite suitable for various insulating functions. More recently, the "glow-wire" apparatus has been used at lower temperatures, but there are still some doubts concerning its usefulness.

This special committee has also



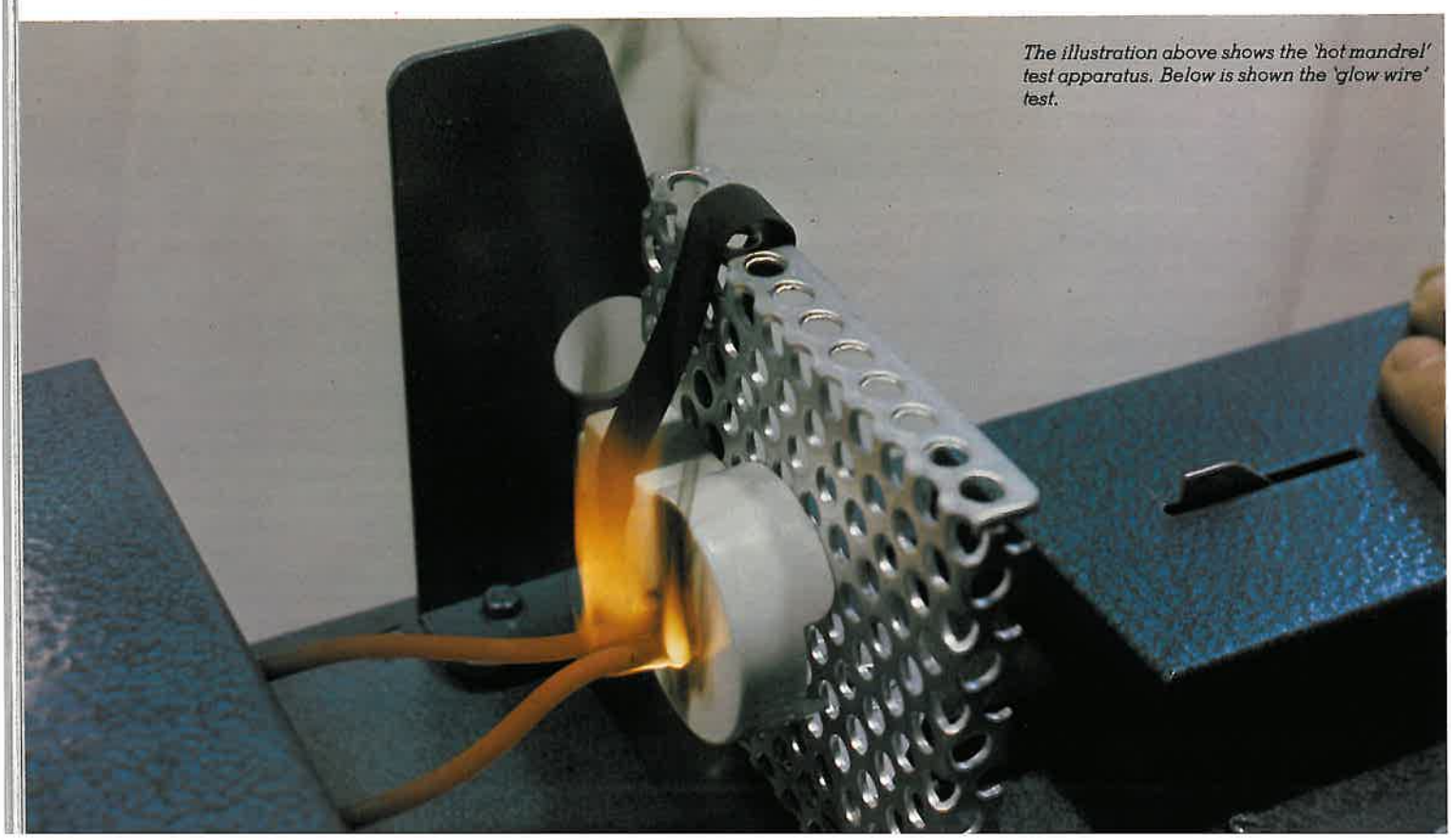
considered "design" tests in those cases where the material failed the pre-selection test and these design tests have included, among others, the 'bad contact' test for screw terminals, at one time known as the 'red sparking' test. This is a good test in theory but very difficult to apply in practice. Other design tests which have been considered involve the use of a "pyro-capsule" for use within insulating enclosures.

Internationally specified tests.

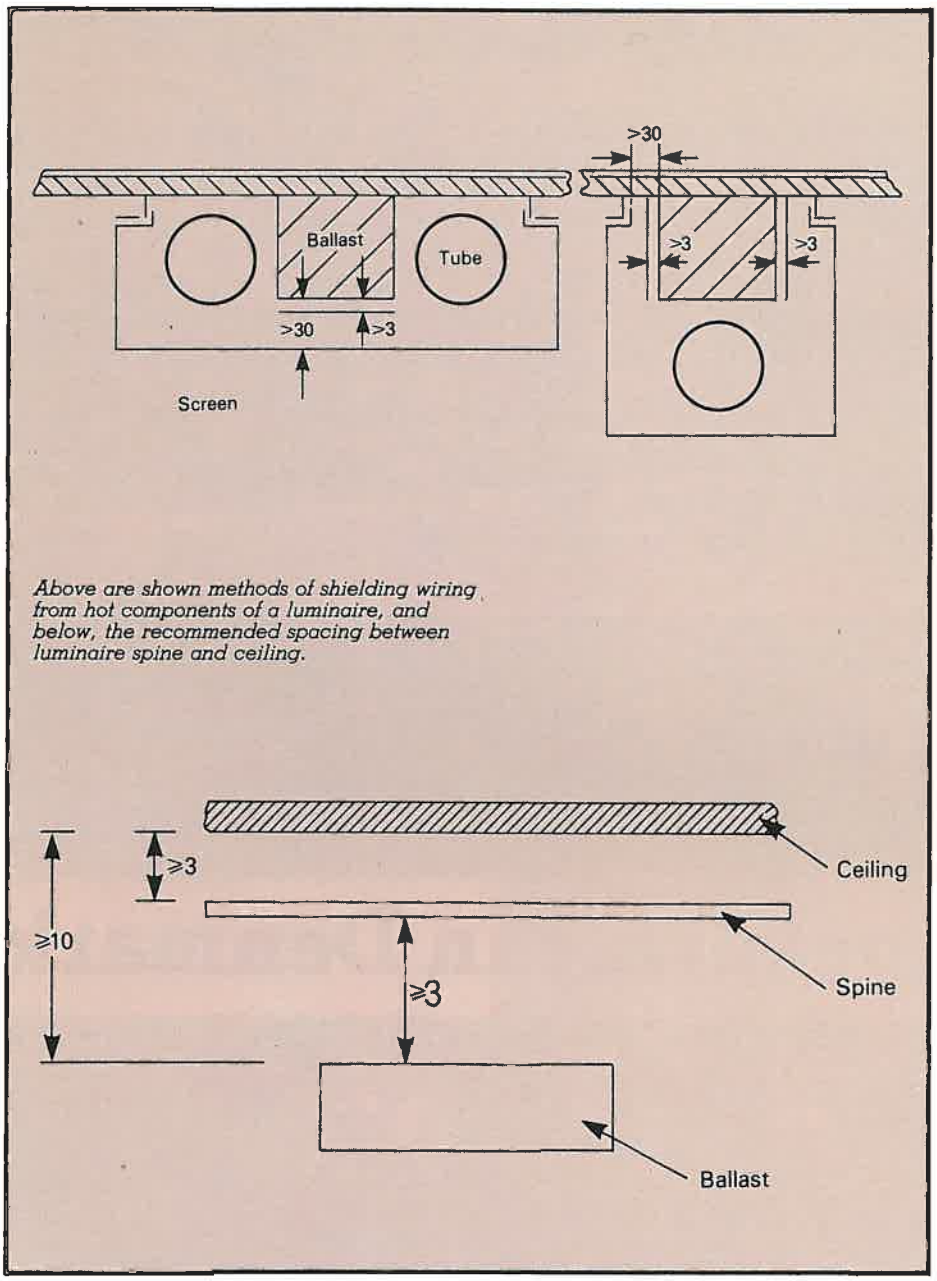
The special committee referred to above has still to come to some firm conclusions concerning various fire tests and in the meantime the International Committee dealing with luminaire safety requirements decided that a system of fire tests should be included in IEC 598 to ensure uniformity in testing luminaires throughout the world. The luminaire fire tests which have been internationally agreed are as follows:—

(a) **Gas flame test**

Parts of insulating material which retain live parts in position, for example terminal blocks, lampholder mouldings in which the terminals are held etc, are subjected for ten seconds to a butane gas flame which is 12 mm long from a burner consisting of a tube having a bore of 0.5 mm. The butane gas flame is then removed and any resulting ignition of the test material must extinguish itself within 30 seconds and any burning drops from the sample must not ignite a piece of cottonwool gauze which is arranged 500 mm below the test sample. The "burning drop" requirement does not apply if the construction of the luminaire



The illustration above shows the 'hot mandrel' test apparatus. Below is shown the 'glow wire' test.



Above are shown methods of shielding wiring from hot components of a luminaire, and below, the recommended spacing between luminaire spine and ceiling.

would prevent such burning drops from escaping. This test has also been called the "Hypodermic needle flame" test and simulates the flame from a household match.

(b) **The hot mandrel test**
Insulating material which does not retain live parts in position but which provides protection against electric shock, for example the cover for a terminal, starter switch canisters, etc. are tested with the "hot mandrel" apparatus. The mandrel which is heated to 300°C fits tightly in a conical hole reamed in the test sample.

A high frequency spark generator is then used to produce sparks at the upper surface of the sample adjacent to the mandrel, and neither the sample nor any gas produced during the heating must be ignited by the sparks. This test has for some years been included in CEE specifications, including CEE 25 but it has been open to criticism mainly due to inadequate detail for the spark generator. However IEC 598 requires that the spark generator shall produce only sufficient energy to ignite the heated sample or the gas produced and it shall not ignite an unheated sample. Further details concerning the spark generator will be included in the specification in due course.

Parts of luminaires which cannot comply with these tests

There are some insulated parts of a luminaire which cannot be covered by either of the tests described above, for example lighting shades and diffusers which do not provide protection against electric shock. In this case the manufacturer may choose either to comply with the 300° C hot mandrel test or alternatively to ensure that his luminaire design provides at least 30 mm spacing between the plastics material and any heated part of the luminaire (e.g. ballasts under failure conditions or parts of filament lamps) which could raise the plastics material to its ignition temperature. If the 30 mm spacing is not possible the flammable material must be protected by a screen at least 3 mm from the heated parts and this screen is required to withstand 350° C and must not have any holes.

For full details regarding these fire tests the reader is referred to IEC 598. No doubt when the special International Committee has come to a conclusion their proposal will be taken into account for a possible revision of IEC 598.

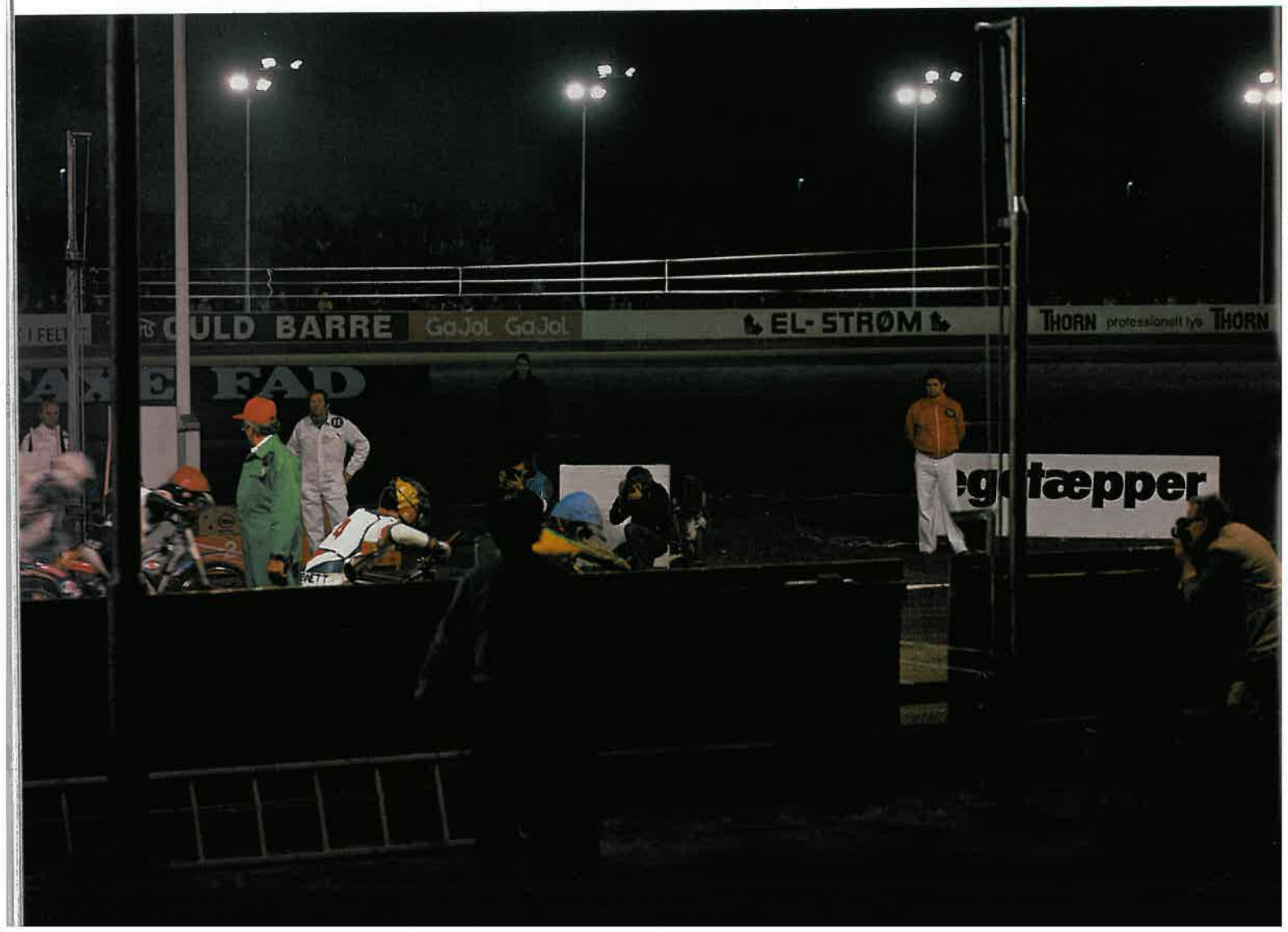
Limiting temperature of mounting surfaces

The above mentioned tests are obviously of great importance to the user by reducing the fire hazard for the buildings in which the luminaires are installed. There is in addition a very important requirement which although not coming under the heading of "Fire Tests" nevertheless reduces the risk of a building fire due to a luminaire. This is the test in Section 12 of IEC 598 Part 1, which limits the temperature of a normally flammable surface on which the luminaire is mounted to 130° C for fluorescent and discharge lamp luminaires and 175° C for filament lamp luminaires. The 130° C limit is one of the new requirements for luminaires marked with the ⓕ symbol and relates to conditions when built-in ballast or transformers fail at the end of their life. Compliance can be by one of three methods; the provision of a thermal cut-out in or on the ballast, the use of a 'cool' ballast, or spacing the ballast away from the ceiling.

Conclusion

In addition to the above mentioned *luminaire* fire tests, many tests are specified for the materials used in construction of luminaires and of buildings. The Thorn Lighting Test House at Enfield is approved by the UK Government (DoE) for certain of the tests on plastics materials, including BS 2782 Part 102c, and 508 D mentioned earlier in this article, which is of considerable importance to the company, for example, in obtaining approval of emergency lighting luminaires. It is important to distinguish between the functions of this type of test laboratory, which tests materials and luminaires to check that they comply with government specifications and the tests made on prototypes during the development and early stages of manufacture of luminaires. Both types of laboratory are housed in the same building, but they operate quite separately from one another.

Lighting a speedway in Denmark



A interesting installation has recently been completed at the Vojens Speedway in Denmark specially for the Danish World Champion, Ole Olsen. The manager of the speedway centre, Mr. Age Sondergaard, specified an installation to give a sufficiently high illuminance for colour television and of good enough quality to avoid obvious variations in the lighting along the track.

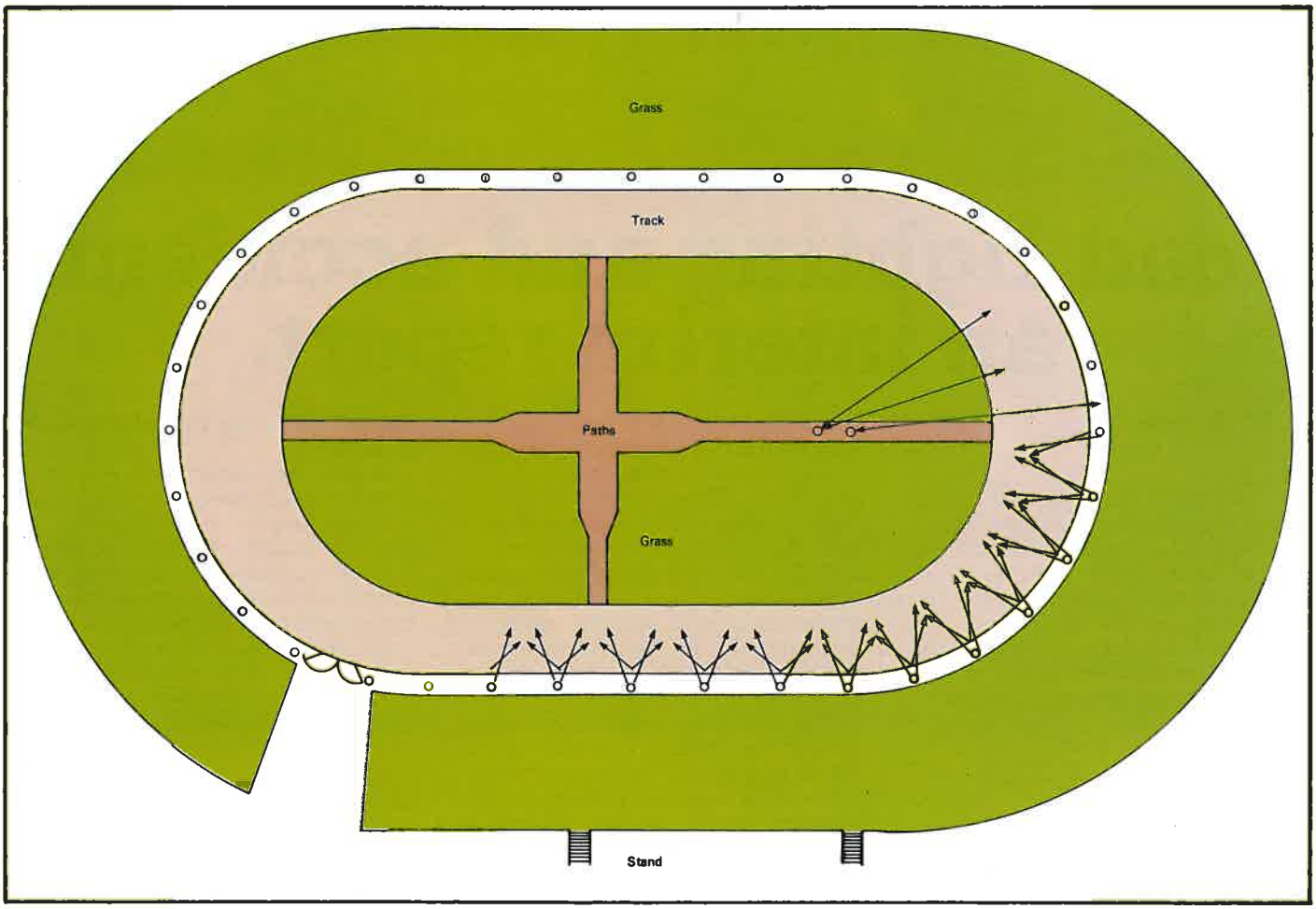
The scheme put forward by Thorn comprised 36, 8m columns, each with a 2.25m arm, and carrying 2 Thorn Haline 1500W tungsten halogen projectors on the arm and two 2000W on the column, giving a vertical and horizontal illuminance of 500-600 lux on the track.

Except in the section immediately facing the stand, spectator areas were lit by 500W Sunfloods, mounted on the back of the columns as can be seen in the black and white photograph.

The objects mounted lower down on the columns are loudspeakers for the public address system.

The scheme was planned with the aid of a computer print-out by Thorn Belysning of Sweden and installed by J. Buch Petersen.

On the facing page are a general view of the course, while below, competitors line up for the start. The plan on this page shows how the floodlights are arranged around the track.



Measuring the luminance of the road surface and surroundings.

Road lighting and accidents, an interim report.

A. M. Marsden

Dr. Marsden is Manager of the Jules Thorn Lighting Laboratories. The work described in this article forms part of the programme of the Transport and Road Research Laboratory and the article is published with the permission of the Director, on the clear understanding that any views expressed in it are those of the author.

In an earlier issue of Lighting Journal (No. 18, Winter 1977) Hargroves and Green described the creation of a mobile road lighting laboratory which was travelling around the country making detailed measurements of road lighting conditions. The resulting road lighting data was to be compared with the corresponding accident data for the same stretches of roads to see which, if any, of the various measures of road lighting quality (quantity of light, uniformity, glare, etc.) are related to the frequency of accidents.

The laboratory is still travelling around the country, and data is still being processed, but already some interesting results are beginning to emerge from the work, results for a very common class of road — two-way roads with a 30 mph speed limit, under dry conditions.

Factors affecting the interpretation of data

Before examining these results, it is important to realise that this work is attempting to isolate from accident figures the effect of one of a large number of things which may contribute to or prevent accidents. If there have been 60 accidents by night on a particular stretch of road over 3 years, how many may be a consequence of sub-standard lighting rather than due to a mechanical failure on a car, or a drunken driver, or an ill-adjusted opposing headlight?

Another consideration is the interpretation of data. Even if, say, the amount of lighting on the surface of the road in a town centre

had some influence on accidents, no-one would expect the data for 10 identical stretches of road with different lighting levels on the pavement to follow the pattern of Fig. 1a. The results would most certainly be "noisy", as in Fig. 1b, and the exercise of discovering whether or not L and A are related is of necessity a statistical one.

If there is a significant trend to be extracted, a much larger sample size than ten would be needed to overcome the amount of "noise" in road accident data.

Deciding the test parameters

A preliminary analysis of the data which had already been acquired in this work suggested that a target number of the order of a hundred 1 km lengths of road would be desirable, with accident figures for each being available for a period of 2 or 3 years. The accident statistic to be used would be the ratio of accidents in the dark to accidents by day, and it would be advisable to attach more weight to the results where the value of dark: daylight ratio is more reliable (sites with a greater total of accidents).

As was mentioned in the earlier article, it was adjudged invalid to combine the data for different classes of road (e.g., 70 mph dual carriageway and 30 mph 2-way roads). Furthermore, because the lighting situation for a wet road is so different from that for a dry road, it was clearly necessary to treat these conditions separately: happily, accident reports do differentiate these conditions.

To date, measurements on dry 30 mph roads have been carried out on over 100 sites, but changes in weather, instrumentation failures, or excessive traffic have resulted in only 41 producing reliable measures of all the eight lighting quantities being studied. Reliable measures of three quantities (average road luminance, average surround luminance and overall uniformity) have been obtained for 74 sites, and average road luminance for 89.

Glare, variations of Luminance and horizontal Illuminance

Included in the lighting quantities logged for the 41 sites are measures of discomfort glare and "site inhomogeneity", this last term being an indicator of how widely the average luminance of a stretch of road ahead of the vehicle varied through the site. The dark : day accident ratio was not significantly related to either of these factors.

Also included were measures of average horizontal illuminance and average vertical illuminance along the line of travel of the vehicle. These had some relation with dark : day accident ratio, but not as clear a relation as the average road luminance or as the luminance of the surrounds. It was noted that these two values of average illuminance and the two values of average luminance were highly inter-correlated, as might be expected when all the lighting installations were supposedly in accord with the British Code of Practice, in which little variation is allowed in the light distribution from lanterns.

The importance of average road luminance

Average road luminance appears to be a decisive factor, for in all analyses of the sites, the 89 or the 74 or the 41 at which it was measured, the same pattern emerged, — a falling accident ratio with increasing luminance. This is portrayed in Fig. 2 for the 89 sites. The larger points represent those sites which had a greater total number of accidents (giving greater confidence in the accident ratio).

The step function is derived by splitting the data into equal numbers of sites (30 at level 1, 29 at level 2, 30 at level 3) and calculating the weighted mean accident ratio for each group. It is seen that the road luminance must be in the highest level before a useful reduction of accidents occurs.

The best-fitting exponential curve

Fig. 1: Noise

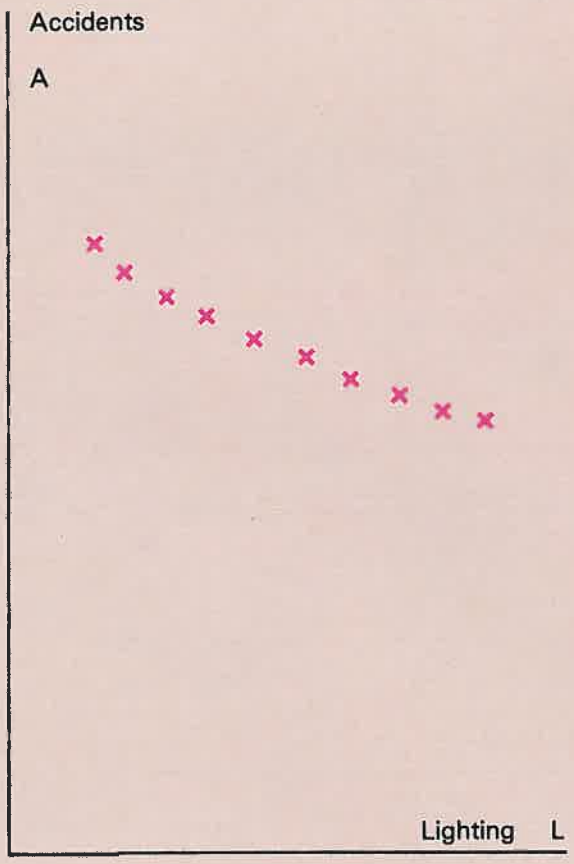


Fig. 1a

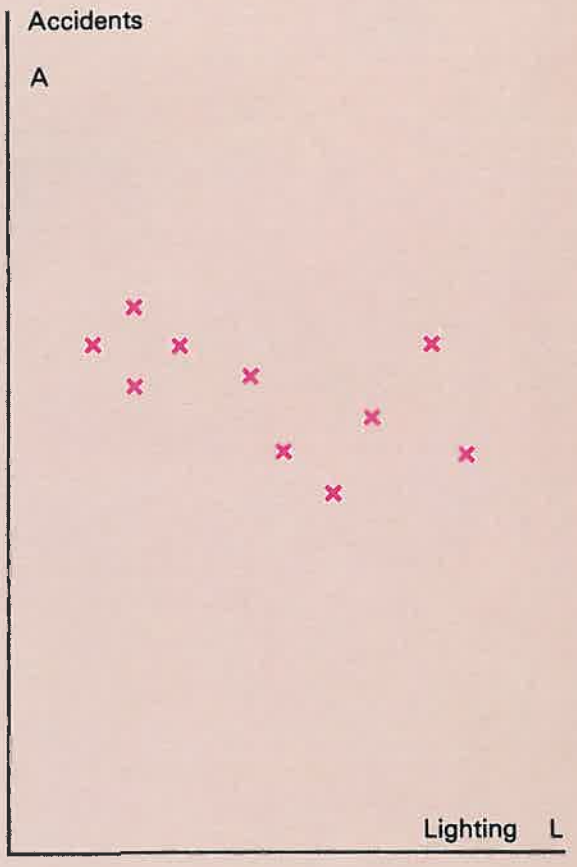


Fig. 1b

for this data (A = 0.65 exp.—0.42L) shows a 20% reduction in accident ratio for an increase of ½ cd/m² in road luminance.

A consistent pattern also emerges from the surround luminance data, but this is not necessarily an additional finding: surround luminance correlates very strongly with average road luminance.

The blunt conclusions about the quantity of lighting and accident rate can be expressed in one of two ways: (a) roads having a luminance in the range 1.2 to 2.0 cd/m² have average accident ratios some 20-30% lower than those with luminances below 1.2 cd/m² or (b) roads with surround luminances over 0.5 cd/m² have accident ratios averaging 20-30% less than those with less bright surrounds.

Further Work Projected

Dark : day accident ratio also appears to be related to overall uniformity, but this is the subject of further examination as the relationship for the two sets of sites (41 and 74) do show some differences.

Work on wet roads is progressing. Lighting measurements here are not as straightforward as on dry roads, firstly because a much greater luminance range is involved, secondly because there are different degrees of wetness. It is hoped to present the conclusions of this wet road work in a later issue of LJ, by which time the processing of dry road data should also be complete.

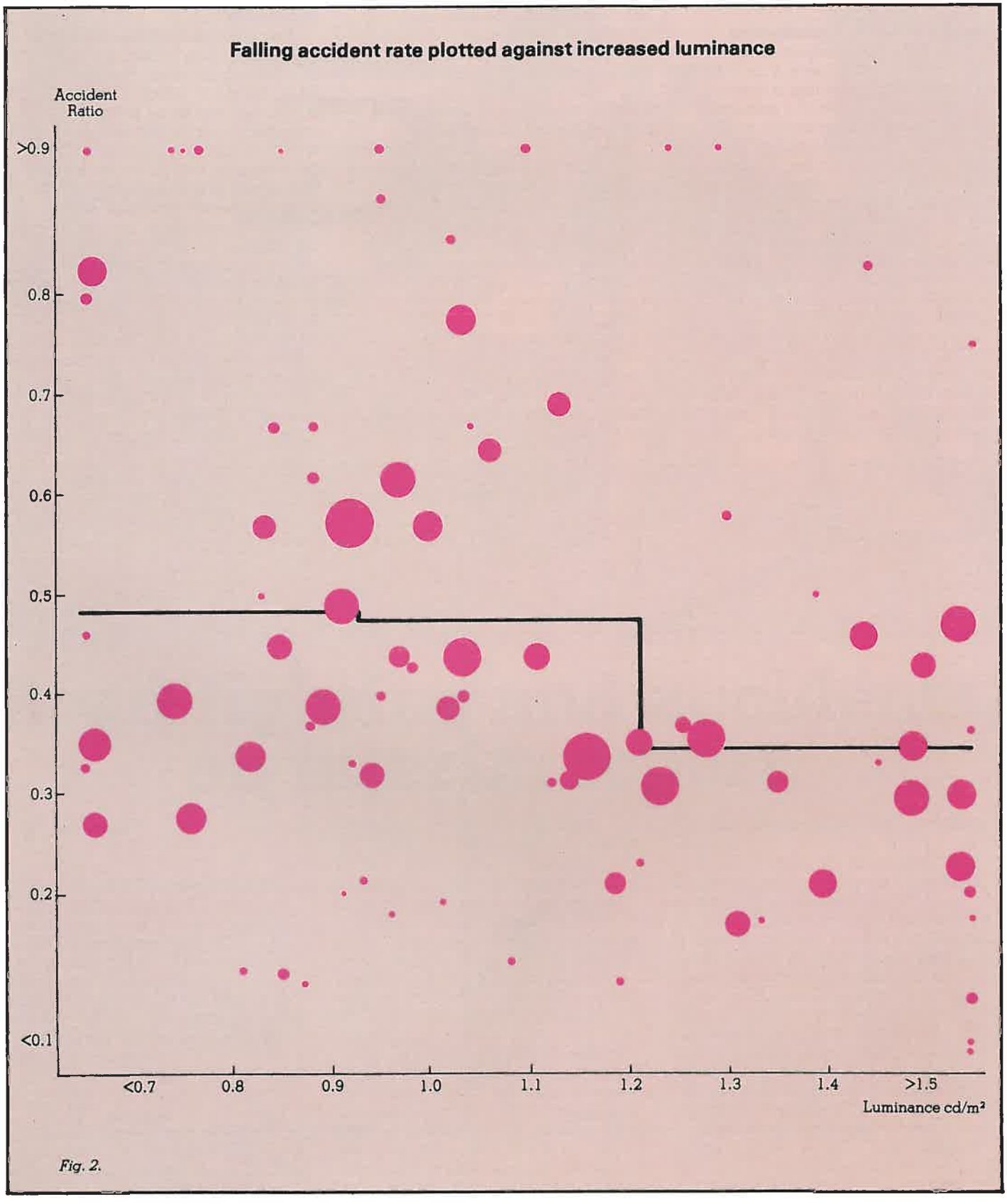


Fig. 2.

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