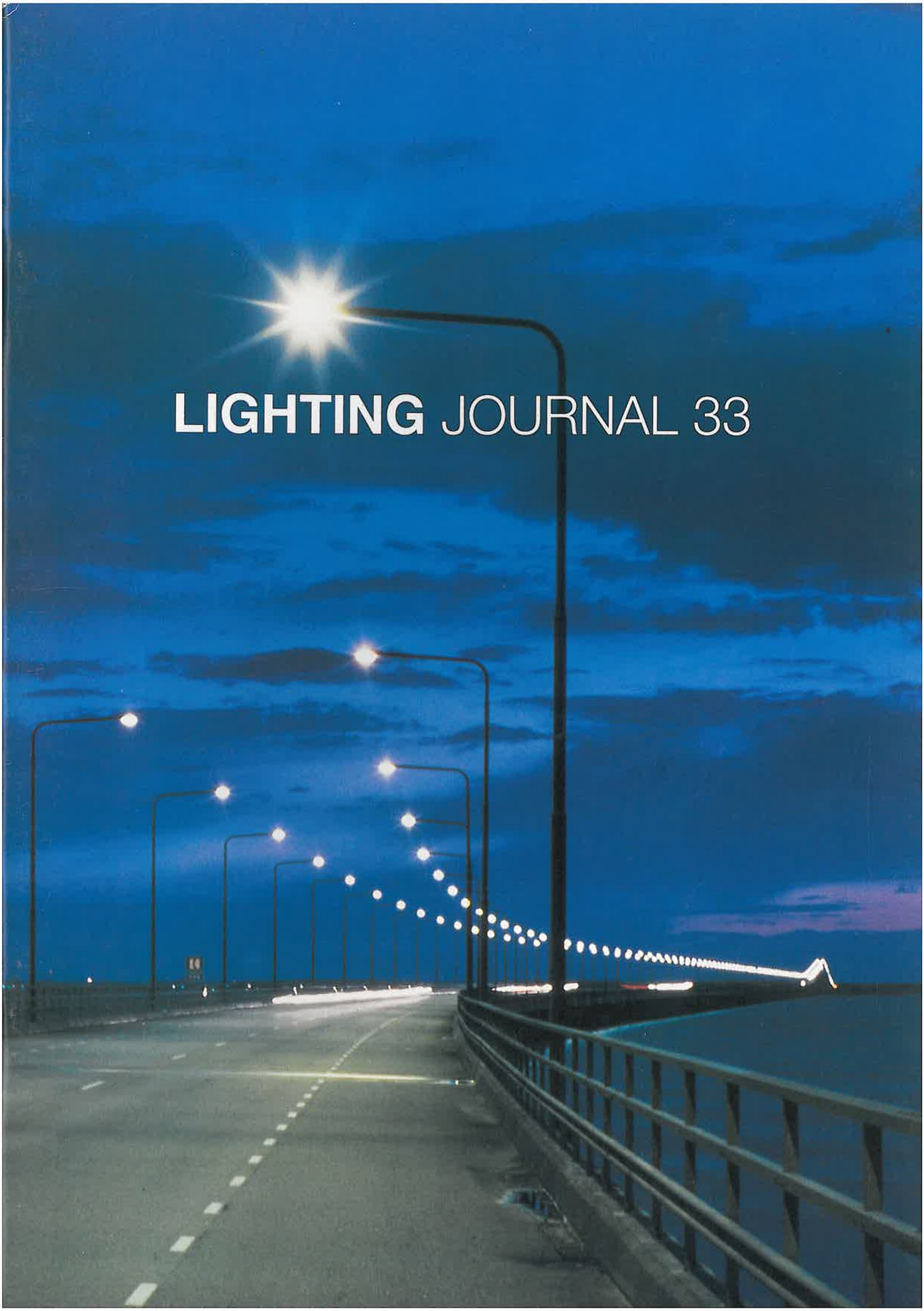
LIGHTING JOURNAL 33



LIGHTING JOURNAL 33

SPRING, 1992

Front Cover: *The longest bridge in Europe, some 6km, linking Sweden with the Island of Öland in the Baltic Sea. It has been relit with nearly 600 high pressure sodium lanterns reducing energy consumption by 35%.*
The inside cover features twelve hazardous area (Zone 2) floodlights at the Glenmorangie distillery in Tain, Ross-shire where the world famous malt whisky is produced on the shores of the Dornoch Firth.
The floodlights, which incorporate 250W high pressure sodium lamps and achieve 300 lux were chosen by NIFES consulting group because of their suitability for the hazardous area classification at the distillery and for ease of maintenance.
The SON lamps with their golden colour, highlight the copper work on the stills, and the overall effect has greatly enhanced the appearance of the Still House, which receives many visitors.

Back Cover: *The Royal Bank of Scotland's building in St Andrews Square in Edinburgh dates back to 1772 when it was originally built as a private dwelling.*
The hall with its magnificent dome, pierced with tiny star shaped windows, was formed in 1858 and is now used as the impressive Banking Hall.
Illumination is achieved from eight powerful 1500W metal halide floodlights, mounted two per corner behind special decorative mouldings. The floods are fitted with reflectors which disperse the light evenly and allow it to gently 'run back' over the curvature and height of the ceiling. "Hot spots" and glare at low level have been completely avoided and the choice of light source, with its excellent colour rendering, displays the colour scheme perfectly. The inside back cover shows the beautiful 15th Century statue of "Neptune" to be found in the City of Bologna sensitively floodlit by 32 underwater projectors with 50W halogen lamps.

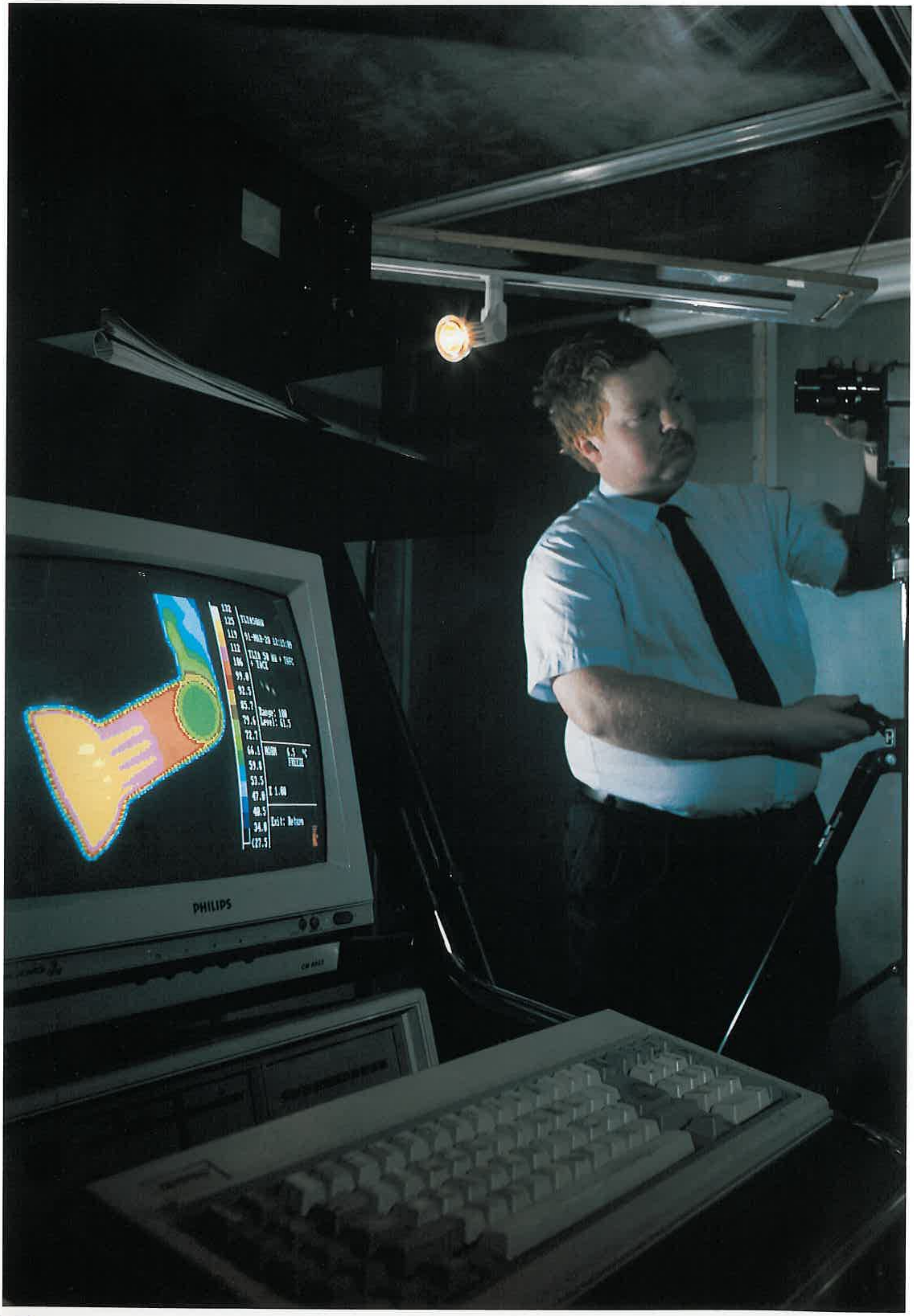
today's lighting market demands continual innovation. It requires manufacturing systems which are cost efficient and flexible. It calls for shorter delivery time and a consistently high level of product quality. In fact, the dominant factor in lighting will continue to be quality.
To meet these rising expectations companies must not only be able to produce aesthetically acceptable luminaires on time and to cost but also be adept at predicting product safety, performance and reliability at an early stage. Increasingly this calls for the use of computers. Our first article looks at some of the newer computer techniques which are being used in modern product design, development and application.
In parallel with such product developments, lighting installation design has also been influenced by the drive for better quality. For instance office lighting must be suited to VDT operators and be in line with the requirements of new EC health and safety legislation.The next two articles examine such topics detailing commercial lighting in general and giving practical guidance for the lighting of visual display areas.
That a lighting installation can provide energy savings without compromising quality is borne out in the next article which describes the final EMILAS awards.
From there we go on to examine the latest study into better street lighting looking at the effect on community safety and the quality of the local environment.
Finally a glance at some impressive lighting installations around the world completes an issue which we hope provides something of interest for all our readers.

Contents

Published by
THORN Lighting Ltd
Public Affairs Department
Elstree Way
Borehamwood
Herts WD6 1HZ

Designed and Printed by D H Publicity

Editor: H King


PHILIPS

Left: *Thermal imaging techniques involve the use of an infra-red camera linked to a computer. Here the product on thermal test is a low voltage tungsten halogen spotlight.*

Below: *Finite element stress analysis. Shown is the modelling of a section of an IP65 enclosed fluorescent luminaire, including the body, diffuser, gasket and diffuser clamping toggles, prior to the production of a prototype. Stresses and deflections are predicted and the parts can be optimised for specific materials.*

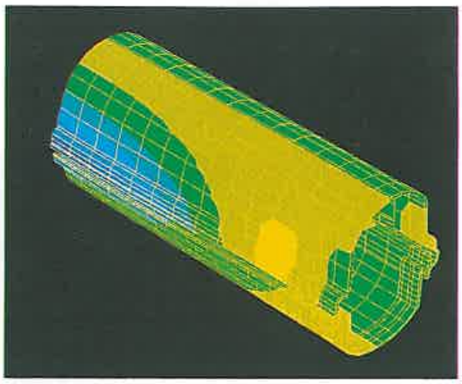
COMPUTERS SIMULATE MODEL TESTING

BROCK HOARAN IS CHIEF MATERIALS ENGINEER OF THORN LIGHTING AT SPENNYMOOR

The use of computers in modern product design, development and application is constantly evolving.
Computer aided design (CAD) and computer aided manufacture (CAM) have already become established tools and indeed computers are an essential part of the control and data acquisition for photometry.Other recently introduced techniques include mould flow analysis and thermal imaging. Major inroads are also being made in optical design and visualisation.
The next major application of computers is the simulation and testing of models to allow more reliable pre-production models of new luminaires using finite element analysis. These simulations will enable flaws in the design to be identified and corrected at an early stage, before physical models and tools are actually made.
This article outlines the newer techniques and shows the major input that they will make to the development process in future.

PRE-PRODUCTION MODELLING

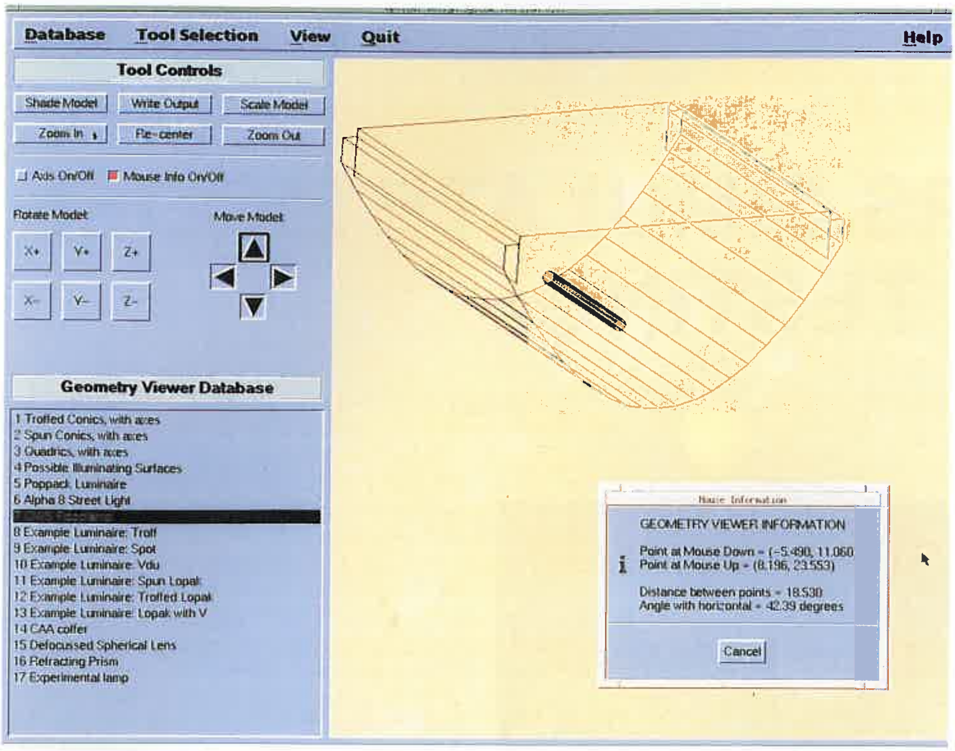
Until recently, once the initial design of any new product had been agreed, it was necessary to manufacture one or more pre-production models to assess the viability of the design. These models would be subjected to various thermal, static and dynamic loading tests as well as photometric trials. As a result, refinements or major changes would be introduced.A lot of problems with new designs only emerge during this pre-production testing stage and can lead to costly re-design, model-making and testing coupled with crippling time delays.
(i) Stress Analysis: A new computer programme now being used uses finite element stress analysis to allow components - or even complete assemblies of different materials - to be modelled and loaded at an early stage in the design. In this way refinements can be introduced and different options tried before any models have been built. The technique also allows stress levels and deflections to be optimised so that adequate material thicknesses are achieved throughout the structure without over or under designing.
Thus a better understanding of the



mechanical performance of luminaire components can be obtained during the feasibility stage.
Starting with a CAD drawing of the product or a solid model, the program allows the proposed structure to be broken down into a mesh of identifiable lines, areas or solid elements - beams, plates, pipes, shells etc for which the stresses and displacements under load can be calculated. The necessary data on the material and all geometric factors are fed into the computer and the model is loaded hypothetically to simulate actual conditions. The programme then calculates separately the stresses and displacements imposed on each of the elements and the complex interactions between the elements of the whole. Thus a total picture is built up.
It sounds simple, but in reality is quite complex as the program is very user-dependent. For instance, the choice of element type and size, and the nature of selected mesh, markedly affect the result obtained. In a complex model,stress levels within 5% of reality are considered a 'good' analysis. It is also possible to zoom in on critical areas for more detailed an-alysis, take sections and rotate the model.
The calculation can frequently be simplified by symmetrical design, which enables the analysis to be restricted to one half of the model; by ignoring any sections of the model which have no influence upon stressing; and by simplifying certain shapes. Indeed, greater accuracy can often be obtained with a similar model.
A powerful feature of the ANSYS programme selected by THORN for its finite element stress analysis is an ability to carry out analyses for a complete structure comprising components of different materials. For example it can be used to model a complete luminaire including the canopy, diffuser, gasket and diffuser clamping toggles.The effect of the sealing gasket and the toggles is an integral part of the calculation.There is even provision to take account of gaps between components.
In the past, the clamping toggles have been over-designed. Not only has this resulted in unnecessary use of material but it has also resulted in stress cracking of the diffuser when clamping was too rigid. Use of the ANSYS program should overcome such problems and enable the effect of different clamping arrangements to be assessed on-screen prior to model-making.
The two main results obtained from the analysis are the stresses in the structure and the displacements, or deformations, in three dimensions.
The analysis can include both metallic and non-metallic materials.
The program is capable of dynamic as well as static analysis. This means that it can be used to simulate vibration, for example, of street lighting luminaires.
(ii) Optical Design: A similar approach can also be applied to the design of luminaire optics. Using a CAD drawing of an optical system, a design program will select a number of points on the light source and follow rays from these points as they are reflected and refracted within the optical system. As a result it can build up an intensity distribution plot for the proposed optic resembling that which would be produced by photometric measurements on a real system.
The program operates in three dimensions and can handle specular and diffuse reflection and refractional boundaries.
As with the finite element stress analysis program, the optical design program can by-pass the initial prototype and photometric testing stage and allows reflective and refractive elements to be manipulated in software to achieve a required distribution of light. Only when the optic has been optimised in the software will the prototype be constructed.
The optical design program provides data in a format that is compatible with existing

COMPUTERS SIMULATE MODEL TESTING

At the top of the page is an optical design programme for a floodlight reflector. The discharge lamp arc tube is clearly seen.



Once a design has been created and optimised it is still important that it can be fabricated. Mould flow predicts whether parts can be made. Illustrated is the prediction of fill for a road lantern bowl. Early designs (left) highlighted the rapid cooling of material on the bowl edge which could cause brittleness when installed, the bowl being under pressure when clamped. The final flow pattern (right) is even with no cool spots occuring.

lighting calculation software. This opens up the possibility of integrating the optical design program into a CAD/CAM system to enable the optic to be designed, modelled and optimised on the computer, and then the tooling set up for manufacture without a physical prototype ever being made.

PRE-MANUFACTURE

Mould Flow Analysis: Once a design has been optimised, it is important to ensure that the product can be made. In the case of plastics materials, this includes confirming that it can be moulded. Plastics materials flow into the mould through a number of 'gates'. As it flows, the material cools. If flow paths are too great, some of

the material may begin to 'set' before the mould has been filled, resulting in weaknesses or voids in the moulding.
Flow can be improved by changing the number, size or positions of the gates in the mould, or by heating selected areas of the mould or runner system, but sometimes it is necessary to redesign the original moulding and repeat the optimisation process.

A mould flow analysis program was introduced at Spennymoor's moulding plant a few years ago to enable the moulding process to be simulated. The program uses a finite element technique and takes the optimised drawing together with flow characteristics of the proposed moulding material. It then predicts what paths the material will take as it flows into the mould, how long it will take to fill, cooling patterns and pressures, and whether the mould will fill.
The technique allows the company to look at a whole range of moulding materials, analysing the filling characteristics of each without ever producing a real mould and without going through the laborious process of trials.

The combination of computerised finite element stress analysis and optical design plus mould flow analysis at Spennymoor produces a number of benefits:-

- Structural integrity and mouldability can be validated at the design stage and the marketing department advised if a proposed design is impracticable.
- The number of prototype models and moulding tools that have to be made can be reduced drastically, resulting in saving in development costs and reducing development times, in some cases from months to weeks.
- Where necessary, materials from different suppliers can be compared directly. Similar analysis services are offered by most materials suppliers, but usually for their own materials. Only by in house analysis is it possible to compare competing materials on an identical basis and ensure optimised material selection.
- The facility with which the analyses can be carried out also means that proposed luminaire designs from outside designers can be validated.
- Customers and even decision-makers within the company itself are more inclined to accept the hard data produced by a computer analysis especially as it can be presented in a visual form that is easily understood.

THERMAL IMAGING

This element of "seeing is believing" is one of the benefits of the recent introduction of infra-red thermal imaging techniques for the thermal testing of prototypes.
Traditionally, thermal testing has involved the use of thermocouples located at strategic positions on the luminaire to record surface temperatures. Whilst experienced test staff have a reasonable knowledge of likely hot-spots so that they know where to position the thermocouples, it is impossible to identify peak contours accurately without employing an excessive number of thermocouples.
Recently, thermal imaging techniques have been introduced to assist with prototype testing. This involves the use of an infra-red camera and a computer to record, store and analyse thermal data. The thermal imaging process produces a picture of the luminaire overlaid with coloured temperature contours. The image provides instant indication of the precise location of any hot-spots together with a readout of temperatures.
The camera can view the target from any angle in order to build up a complete thermal picture. It can also zoom in on any critical locations and freeze the record.
The technique means that customers can be shown a graphical plot of the product with temperature contours and hot-spots clearly identifiable.

LIGHTING VISUALISATION

A computerised visualisation program which builds up a picture of a proposed lighting scene is at an advanced stage of development at the THORN EMI Central Research Laboratory.
There are already numerous computer

Below: *Visualisation. Computers can now predict the appearance of a room, such as this bar area, under the influence of particular lighting systems.*
Bottom: *Figure One shows the future for integrating computer programs into a unified system for design, development, manufacture and testing.*

programs designed to carry out the necessary calculations for simple lighting schemes but the visualisation program is a more sophisticated package capable of producing a colour image of any complex scene complete with realistic furniture and textures as they would appear in the proposed lighting installation.

It starts with a CAD drawing of the scene. For each element within that scene the colour, reflection characteristics and texture are fed into the computer. From this the computer will draw a colour picture of the scene. The lighting can then be "installed" on the computer model by feeding in the proposed locations of the luminaires and their photometric data. For the THORN luminaires, this latter information is stored on computer so that a simple identification of the luminaire type will be sufficient to call up the necessary data.

The program then looks at the intensity distribution from the luminaires, divides the scene up into a matrix of "patches" and first calculates the brightness and colour of each patch in the scene due to direct light from the luminaires. Next, unlike existing computer programs for lighting design which consider only average light reflected from the room surfaces, the visualisation program considers reflections from all elements in the room and can continue to repeat the calculations for successive inter-reflections from surface to surface. The user can determine the number of iterations that are carried out.

The program can output the data as a colour picture of the scene, accurately portraying the effect of the lighting installation, or as a plot of the various lighting levels.

The visualisation program can be used with internal and external scenes, provided those scenes can be reduced to a CAD drawing with the various colours, reflectances and textures identified. It can also take full account of diffuse daylighting.

The program makes use of parallel processing techniques with the calculations shared out between 15 transputers which communicate with each other. It can also operate in serial form on a Unix-based workstation.

The visualisation program is intended for large-scale projects where it will enable architects and lighting designers to visualise the scene with a high degree of accuracy. It is a design tool rather than an engineering tool and provides an accurate picture of lighting effects which many lighting engineers visualise instinctively. It allows a lighting engineer to express his ideas to a client in visual terms which may be more meaningful than just lists of numerical values. One of its main benefits will be to "sell" an aesthetically pleasing scheme to the customer.

THE FUTURE

The finite element stress analysis, optical design and mould flow analysis programs are already beginning to yield benefits in speeding up lighting development times as the time-consuming processes of repeated model testing are cut to a minimum. But there are other criteria, notably thermal stress, that could benefit from similar treatment. Integration of the various analysis programs into a common system with computer aided design will further enhance the benefits while international networking will ensure that the data and analysis facilities are available to each of the company's operating units.

Thermal stress analysis is the next step in the finite element stress analysis program and one which the ANSYS program is capable of handling.

Thermal testing consumes a great deal of development time. If the temperature distribution and heat flow characteristics produced by lamps, ballasts, forced convection and ambient conditions can be calculated for the various materials and structures, it will go a long way to clearing one of the remaining bottlenecks in luminaire development.

Finite element thermal analysis is more complex than stress analysis but it is anticipated that ANSYS will be invaluable in allowing the effect on structural analysis to be determined also.

The potential for integrating the various programs into a unified CAD/CAM system is shown in Fig1. The CAD system will generate the three-dimensional model which will then be optimised by the finite element stress analysis, thermal analysis, optical design and mould flow analysis programs. The optical design program will interact with the photometric database used in a wide range of lighting software including the lighting visualisation program. Once optimised, the model can be used in the computer aided manufacturing program and the production of mould tooling. The whole can be networked internationally to ensure a cross-flow of data between manufacturing and sales units worldwide.

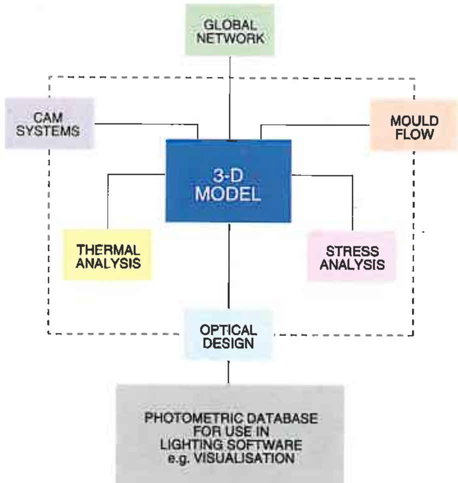


FIGURE ONE


Tea
Breakfast Cereals
Washing Powders
Toilet Tissue

Retail areas now rarely use horizontal counters-merchandise is displayed in vertical fashion and the illuminance on vertical surfaces is increasingly important. Tesco, opposite, uses suspended fluorescent fittings with low brightness symmetrical reflectors at its Bicester superstore in Oxfordshire. A powerful 1200 lux average vertical illuminance results with 800 lux provided horizontally at floor level. The fittings house 40W 2L lamps operating off high frequency electronic ballasts.
Below: *The pharmacy area of the Royal Free Hospital, London now lit by recessed fluorescent fittings with high frequency electronic ballasts and 1200mm 36W lamps. The previous scheme relied on 1800mm 75W surface mounted fittings. Illuminance has increased from 550 to 750 lux and electrical loading reduced by 64 per cent.*

BETTER COMMERCIAL LIGHTING -EFFICIENCY AND PRODUCTIVITY

When we talk about the need for lighting to be efficient and effective some people think immediately of energy conservation or, better still, energy management. But efficient and effective lighting is much more than that.

Lighting has a job to do and it must do it well. It is not there for the benefit of the building but for the benefit of the occupants, and good lighting contributes directly to their efficiency and effectiveness. It also contributes to safety.

But let us start with energy. In the UK, lighting accounts for less than 4% of the primary energy consumed and about 16% of the total electricity consumption.

In domestic and industrial premises, lighting is not a large proportion of the electrical energy consumption, but in commercial premises which include public buildings and offices it accounts for about 50%. With such a large proportion being used for lighting, it would seem, at first sight, a good target for energy reduction.

But is it? Only if the lighting is designed to be efficient and effective in terms of what it achieves as well as what it costs.

AIMS

The principal purpose of lighting is to enable people to see. Unlike temperature and humidity, which must be controlled within fairly close limits for human comfort, lighting conditions can vary over an enormous range, and it is essential to match the lighting standards to the type of work to be carried out. You would not for example, feel too confident about having an operation if you heard that the lighting levels in the theatre had been reduced to save energy.

SICK BUILDING SYNDROME

Complaints by users about the environmental standards in many office buildings - or 'sick building syndrome'- have attracted much media attention during the last few years. An article published in 1989[1] reviewed the current state of knowledge and looked at the building services aspects of the problem. Many factors were found to be involved but poor lighting standards have been identified as a likely contributor.

Investigations into complaints about office working conditions suggest the main lighting related problems are:-

- reflection of lighting equipment and windows in VDT screens;
- direct glare from lighting;
- difficulty in reading written or printed copy with fine detail;
- gloomy and depressing visual environment.

Such concerns can be put into perspective by looking at the results of a recent study conducted by THORN as part of their CSP[2] work. Some 44 offices with a total of 650 occupants were surveyed. Twenty five per cent of the offices failed to meet the basic illuminance requirements of The Chartered Institution of Building Services Engineers

(CIBSE) code; 30% had excessive discomfort glare and 9% had too much light on VDT screens.

Poor lighting contributes to accidents and, more insidiously, reduces the efficiency and effectiveness with which people work. It can decrease morale, increase staff turnover and be a causal factor in industrial action. Lighting in places of work, which is insufficient or unsuitable, directly contravenes the Health and Safety at Work Act.

BAD ECONOMICS

Not only that, it is bad economics. Even in offices only about 0.5% of the total operating costs are spent on the lighting, with the major share, about 84%, being spent on salaries and associated costs.

It is tempting to conserve energy by reducing lighting standards, but this is naive and uneconomic in real terms. Quite clearly, with most of the operating costs being on staff, any reduction in the efficiency or effectiveness of the work force would be counter-productive. What sane businessman would risk losing a percentage of 84 pence in every pound for a potential saving which is likely to be no more than one tenth of a penny.

The greatest and most worthwhile improvements are made by correctly designing lighting systems to provide the most efficient and effective solutions and by managing them so as to maintain that effectiveness.

But even today, a great many people are short-sighted and are only concerned with the capital cost of the installation, without regard to improvements that can be achieved for a slightly higher investment.

Good lighting works well and uses energy efficiently. The refurbished main gallery of the Royal Museum of Scotland is an attractive interior in which good lighting plays an important part. It was a winner of the National Lighting Award competition for Excellence in Lighting Design (see LJ No 30). In other words, the lighting design was judged to be the best in its class. Yet this installation also won the EMILAS[3] competition for Energy Management. But neither of these competitions is the real test of efficient and effective lighting.

The museum has a job to do. It must attract visitors and show the exhibits off to the best advantage. The reaction of visitors to the museum has been excellent and is demonstrated by the million people who now visit it each year. That is the real test of efficient and effective lighting.

Efficient and effective lighting means:-

- Ensuring that the correct lighting standards are provided both in terms of quantity and quality.
- Selecting the correct type of lighting system.
- Using the most suitable lighting equipment.
- Controlling the hours of use.
- And maintaining the system in efficient working order.

OBJECTIVES AND STANDARDS

What are the appropriate lighting standards? The CIBSE in its current Code for Interior Lighting makes sound and sensible recommendations about lighting standards and good practice, with the emphasis very

BETTER COMMERCIAL LIGHTING

The Abbey National has achieved 60% energy savings at refurbished offices in Milton Keynes. Over 600 twin recessed fittings with old 38mm diameter fluorescent tubes and opal diffusers were replaced with some 450 self contained, "intelligent" light fittings. The fittings dim down or turn off individually when they sense that there is enough natural daylight or when they detect a person has been absent from their "zone" for more than 15 minutes. High frequency electronic control gear provides a quality, flicker free lighting environment. Staff reactions have been extremely positive.

Figure One: *Improvements in efficacies of lamp types.*

strongly on the efficient and effective use of energy. It should be compulsory reading for anyone involved in the design or specification of lighting.

Lighting must set out to achieve 3 things:-

- Firstly, people must be able to move about in safety and without risk of accident or injury. This applies at all times and becomes critically important if there is an emergency.
- Secondly, the occupants have things they must see to do. They need to perform certain tasks to an acceptable level. The types of task can vary considerably as can the consequences of errors.
- Lastly, the lighting must help to create the right appearance and atmosphere and it must create the right sense of comfort.

Lighting can, for example, be used to create an intimate atmosphere in a restaurant or a lively one in a fast-food restaurant.

It is easy to think that getting the lighting right is just a matter of achieving the right lighting level but there is much more to it than that. There are many things that must be designed if the lighting is to be correct.

The uniformity of illumination, for example, affects our perception of the space and our ability to see and work efficiently and effectively. Discomfort glare determines how uncomfortable we find the lighting and this, in turn, affects our ability to work and to concentrate without distraction or fatigue.

Good lighting starts with the design objectives, and if they are wrong, no amount of good equipment will compensate.

LIGHTING SYSTEMS

The type of lighting system is important. Don't confuse this strategic decision with the details of which equipment to use. That comes later.

General/Uniform: The traditional way to light an interior is to use a regular array of lighting to provide uniform illumination over the entire working area. However, a large proportion of the space may be devoted to tasks which are not visually demanding - such as walking about, or filing - and it is wasteful to illuminate these areas to the same standard.

Localised: Localised and local lighting systems reduce this waste by relating the positions of the lighting equipment to the work stations to provide high levels at the work station and lower levels elsewhere.

Localised lighting could be used over a production line with a general lighting system in the roof, to light the general area to a lower level for safe movement.

Localised systems are gaining popularity in offices. Uplighter systems, for example, direct light from extremely efficient discharge lamps onto the ceiling, where it is diffused and reflected onto the tasks.

A high lighting level is provided for work stations with lower levels in the circulation space. The elimination of a ceiling supply saves costs and the free-standing uplighters can be relocated when the office layout changes.

Local Lighting: Unlike localised lighting, local lighting provides illumination only over the small area occupied by the task and its immediate surroundings. Some form of general lighting is also needed to provide sufficient ambient illumination for safe movement.

Local lighting must be carefully designed and positioned to minimise shadows, veiling reflections and glare. Units which use conventional tungsten lamps are inefficient and fluorescent fittings are normally a better choice.

CHANGING WORKING NEEDS

Much lighting design has been based on the principle of providing the appropriate lighting level on the horizontal working plane. In many situations, however, the nature of tasks and the way in which building space is used have changed.

Retail areas now rarely use horizontal counters - merchandise is displayed in vertical gondolas and the illuminance on vertical surfaces is increasingly important.

Office work traditionally involved working with paper on flat horizontal desks. The introduction of the Visual Display Terminal or VDT in offices means that part of the working task involves viewing characters or diagrams on a screen in a near vertical position. In addition it is necessary to use a keyboard and usually consult written or printed documents. The various visual tasks are on differing working planes and the brightness of the screen, keyboard and printed data may differ widely. The work which the eyes are expected to perform is different, more complex, more demanding and can cause problems. A Gallup Poll[4] carried out in 1990 suggests that 27% of office workers operating VDT's suffered from eye strain and lighting-related problems. Significantly the Poll found that 56% of those asked said that the lighting in their offices had not been changed since VDT's were introduced. For example, fluorescent lighting fittings with low brightness attachments or uplights had not been installed. More than 20% of those interviewed said the lighting in their offices had not been modernised for six or more years, and 11% thought it had not been redesigned for over 10 years.

Fortunately for office workers an EEC directive requires legislation to be introduced by 31st December 1992 that details employers obligations to those who use visual display work stations. Such is the seriousness and complexity of this issue that the following article gives a comprehensive explanation of the problems associated with, and lighting design requirements, for visual displays.

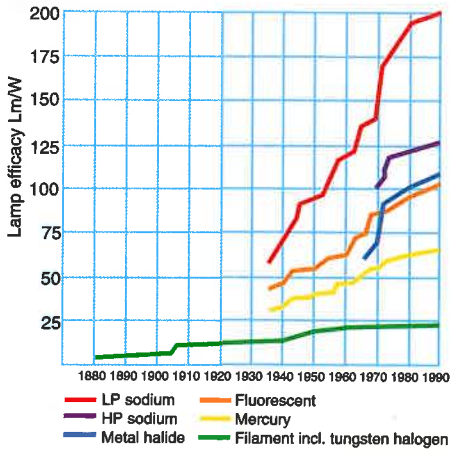
DEMAND FOR FLEXIBILITY

In commercial office buildings there is increasing demand for flexibility in terms of lighting provision to meet working needs. Variation in occupancy levels of office space during working periods underlines the need to provide lighting exactly when and where required. More frequent changes in office layout and arrangement and the division of space into smaller units requires lighting systems that can readily be altered to serve changed accommodation arrangements.

EQUIPMENT

When it comes to equipment, the choice of lamp affects the range of suitable light fittings but frequently the performance of the light fitting is ignored. For example, many manufacturers make fittings which look similar and use the same lamps, yet their efficiency can vary by a factor of more than 2:1. So it is very unwise to just select luminaires without comparing their performance.

FIGURE ONE



On this page can be seen the County of South Glamorgan's prestigious headquarters building. High quality of all building services and energy efficiency were key requirements. Fluorescent lighting is provided with low brightness louvres which ensure good working conditions for VDT operators. The lighting is controlled by an energy management system providing switch on/off at pre-programmed times. Local override facility permits staff to control individual lighting fittings in line with their working requirements.

The objectives of lamp development have been to improve efficacy (light output for power consumption), lengthen lamp life, improve colour performance and improve optical control. The improvements in lamp efficacies that have taken place are shown opposite.
Detailed information on lamp characteristics is provided in the L.I.F.'Lamp Guide'[5] and

publications from individual manufacturers. Developments of particular significance for interior lighting include:-

- 26 mm diameter fluorescent lamps of improved efficacy and colour rendering.
- compact fluorescent lamps (as alternative to GLS filament lamps and shorter fluorescent lamps);
- high frequency (HF) operation of fluorescent lamps;
- improved efficacy and colour rendering of high pressure sodium and metal halide lamps;
- tungsten halogen lamps (with improved efficacy).

In parallel with these improvements in light sources, there has been a change of approach to luminaire design. Higher cost of electricity has resulted in increased attention being given to luminaire efficiency in terms of both utilisation and light distribution. For fluorescent luminaires, the use of high performance reflector systems giving increased efficiency over diffuser and controller attachments has become common. Apart from improving the light output ratio (LOR) of luminaires, the accurate reflector systems permit effective control of light distribution.

Ranges of fluorescent luminaires are now available incorporating the new compact fluorescent lamps capable of providing light outputs from a compact square luminaire (600mm x 600mm) that previously would have required the use of 1200mm or 1500mm linear luminaire types. One notable trend has been the introduction of uplighter luminaires in a wide variety of types for the provision of indirect lighting.
The development of control gear for operation of fluorescent lamps at high frequency (30 kHz) provides further gains in efficacy and a wide range of lighting management systems is now available to facilitate the provision of lighting in the areas and at the times required (see LJ 32 - A Matter of Control).

MAINTENANCE

Many lighting installations are wasteful and inefficient. Not because of poor design but because of neglect. The abysmal standards of maintenance that many organisations adopt, often result in a 60% or 70% reduction in efficiency. No one would buy a car and not service or clean it yet we do with lighting.
Lighting design in the UK is currently based upon an average or "service" condition. This is the value between maintenance points. In practice, however, the cleaning and relamping does not happen, so levels are well below recommendations and often below safety values. New European practice linked to legislation will introduce "maintenance illuminance" as the design criterion. This is the value which must be exceeded at all material times. An employer who lets his lighting drop below this minimum value will be negligent.

CONCLUSION

Most lighting installations in use today are inefficient. This is mainly due to:-

- Inadequate briefing
- Too much emphasis on capital cost
- Lack of thought during design and installation
- A failure to realise the importance of a sensible maintenance programme.

Both economic pressure and users demand for better quality lighting are dictating more professional attention to lighting scheme design. The basic approach of 'lighting design for areas' is giving way to 'lighting design for people' in terms of their visual tasks at work and their expectations with regard to acceptable visual environments being created.
User demand, not to mention legislation, will cause more emphasis to be placed on proper design particularly in office areas where VDT equipment is in use.
The continuing importance of efficient energy use (on both cost and environmental grounds), together with a need for more flexible application of lighting to building areas, will require the use not only of efficient products but of sophisticated control systems.
The needs of facilities managers to accommodate more frequent changes of building area layout or use of building space require that lighting systems be better engineered to facilitate easy, and low cost, alteration in line with users' requirements.
In economic terms good lighting makes sense - for offices, the total lighting cost is some 0.75 per cent of the annual wages bill. Additional costs of good quality lighting (if any) are covered by small performance /productivity improvements.
These may seem difficult things to measure accurately, but they do occur and they are worth much more to the organisation than mere energy savings. But this isn't a trade off. You can design lighting to provide an efficient and effective environment and you can make it use energy efficiently and effectively. All it takes is a willingness to use good design.

References

1.Sick Building Syndrome - The CIBSE View Building Services Journal (June 1989)
2.Comfort Satisfaction and Performance Index - Lighting Journal 32 (1991)
3.EMILAS - Energy Management in Lighting Awards Scheme - see page 17
4.Gallop Poll conducted for Lighting Industry Federation (1990)
5.Lamp Guide published by the Lighting Industry Federation

Pictured opposite and below is the Royal Hong Kong Police's Regional Command and Control Centre. Following detailed simulation trials a multilamp, dimmable, pendant fluorescent uplight approach was chosen. Combined high and low ceilings posed a particular challenge and led to the special design of both pendant and console mounted uplights housing various combinations of 36W 2L compact fluorescent lamps. The dimmable control gear is housed in purpose made boxes mounted either in the ceiling void or in the console base compartment. A multi-channel dimming system by Quantran provides user flexibility. Emergency lighting is provided throughout the area along with a number of wall mounted 38W 2D compact fluorescent uplights.
Lighting design was by Design Innovations, Hong Kong in conjunction with its associate UK company Communications Complex Design of Weybridge.
***Bottom :** Computer Aided Design Workstation*

GUIDANCE FOR AREAS WITH VISUAL DISPLAYS

On 29 May 1990, the EEC issued a directive which deals with employers obligations to workers who use visual display work-stations. The directive details the obligations of employers and sets minimum requirements for the workstation, the environment and the interface with the operator. Member states are required to bring into force laws, regulations and administrative provisions necessary to comply with the directive.

LEGISLATION

The legislation requires that:-

- The screen shall be free of reflective glare and reflections.
- Suitable ambient lighting is required so as to provide satisfactory working conditions and an appropriate contrast between the screen and the background environment.
- Lamps for secondary activities shall be provided where necessary: they shall be adjustable so as not to cause glare or reflections on the screen.
- Work stations shall be so designed that sources of light, such as windows or lamps and brightly coloured fixtures or walls cause no direct glare and, as far as possible, no reflections on the screen.

Because the directive uses words like "adequate" , "suitable" and "as far as possible", rather than quote quantities or levels, the employer may need to get expert opinion about whether or not the situation will comply.
Several simple surveys in the UK have assessed the percentage of workstation installations which would be judged to be unsatisfactory. They do not give the same estimates because they were carried out in different ways but they suggest that at least 2 out of every 3 workstations fall below standard.
The directive must be implemented by 31 December 1992 and will apply to workstations first put into service after that date. Workstations already in service on that date must be brought up to standard within 4 years. This may seem a reasonable breathing space, but certain points must not be overlooked. Firstly, existing Health and Safety legislation in the UK already covers some of the points in the directive. Lighting in places of work, for example, must be "sufficient and suitable" and the CIBSE lighting guide, LG3 makes detailed recommendations about VDT use and defines what "sufficient and suitable" means when applied to visual displays. It follows from the above, that it is not acceptable to assume that no action is needed until the end of 1992.
Workstations already in service have a longer period in which to be adapted to comply. A workstation is defined as more than just a computer; it is the complete set of hardware and software together with the desk, chairs and other equipment, and their immediate environment. Although the directive is not clear about the definition of a "new" workstation, a reasonable interpretation would be that a significant change to any of the elements of the workstation would call for it to be treated as a new workstation. Thus, for example, it would be wise to interpret a change of software or location as if a new workstation was being put into service.
The above points highlight the legal aspects of this matter, but it is important to remember the purpose of these requirements. If the correct conditions are not provided then workers will not be able to work efficiently or effectively. They will suffer as a result and so will the employer. By failing to provide the right conditions, the employer is wasting his investment in labour, which is usually one of the highest costs in the business.
This article aims to help those who may be involved in the design or operation of workstations. It is not a substitute for the expert analysis and advice that is needed, but it will help the reader to understand the problems and take the correct remedial action in many cases.

INTRODUCTION

If you are asked to judge whether a VDT workstation is acceptable, you will probably concentrate on the type of workstation and the type of display. You may pay some attention to the environment but, as a rule, you will ignore the single most critical part of the installation, the human being using the display. Not only is this component error-prone, but it is also faulty (wearing spectacles ?) and, even if only 20 years old, is old enough to have lost considerable

An example of a practical Display Console showing different types of display device and different viewing angles.
Figure One *:- Size affects visibility*
Figure Two *:- Threshold contrast versus adaptation luminance*

visual ability. Unlike the other components in the workstation, it is unlikely that the operators were tested before becoming part of the workstations.
The basic purpose of a VISUAL DISPLAY is

that human beings should "read" it so that they can extract the required information quickly and correctly.
A typical workstation can be extremely confusing. Self-illuminated displays and indicators that are most legible in semi-darkness will be side by side with mimic displays, printers, and LCD devices that must be well-illuminated. All are normally at different angles and focal distances and some are very directional with narrow acceptance angles. Something has to suffer somewhere, and it is human vision.
The only consolation is that the human visual system is unrivalled at processing inadequate data and making sense of it. The apparent ease with which our visual mechanism sorts out seemingly reliable information from poor data makes us perceive the data to be far better than it really is and masks our difficulties and mistakes. But, there is a penalty to be paid. Like any other work which is too hard it takes longer to do, and it can be tiring, cause stress and errors.
Incorrect lighting can exacerbate the visual problems and correct lighting can reduce them. In places of work, if the lighting or the workstation could be improved and would eliminate or reduce difficulties in seeing, then the employer has a legal responsibility to do so. Good lighting is not a substitute for a good workstation design, but an essential aid.

THE VISUAL MECHANISM

Three threshold factors are important to the visual mechanism:-
Detection - where a person thinks he can see an object but not what it is
Recognition - where he recognizes that it is a person not a pillar box
Identification - where he can identify the detail of the person ie his wife !
In some visual display work, the detail may be at one of these **Threshold** levels, but if we are reading or writing we are concerned with a much higher level of visual ability - taking in complete words and sentences rapidly, we cannot afford to mess about with, is the letter an A or H ? Even when we are just enjoying the scenery we still expect to be above threshold levels of vision.

VISIBILITY FACTORS

When we read a visual display we normally want to do it without effort. Experiments at threshold level show the factors that affect our vision.
These are:-

Size of detail
Luminance contrast of task
Luminance (illuminance) of task
Disability glare
Adaptation time
Colour contrast

These are roughly in order of importance.

SIZE

Size of detail is important. Small detail is harder to read than large detail and, below a certain size, detail cannot be resolved. This varies from person to person. It is not the actual size that is important, but the angular size at the eye. It could be a large object a long way away, or a small object close up. The size of the smallest detail we can see it called visual acuity. It is this that opticians test with their letter chart. We canalso move closer to the work to compensate - if our eyesight can cope with such close work. When people do this is a sure sign of visual difficulty.

FIGURE ONE

CONTRAST

Information with higher contrast is easier to read.
The contrast that we require in order to just be able to see something is called threshold contrast. Below it, we cannot see the object. Even when an object is visible, reducing its size or contrast increases the amount of visual work.

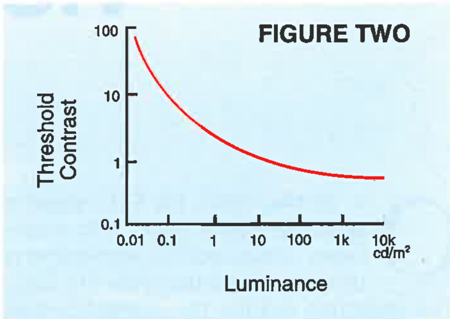


FIGURE TWO

LUMINANCE (ILLUMINANCE) OF THE TASK

Fig 2 shows how the threshold contrast varies with luminance. In normal room lighting (100 - 1000cd/m^2) it flattens off.
A simple example will provide a better "feel" for the relative importance of these factors. Suppose we had some very small faint text on a page in our office and we could just read it. We could roughly improve its visibility by the same amount if we increased:

Size	x2
Contrast	x4
or Luminance	x100

(These figures are not exact and vary with conditions). The moral is that, if poor lighting degrades the contrast of a display, making the display brighter or adjusting the lighting level it is not going to be much good. Conversely, it is vital to provide good lighting conditions to ensure that the effective contrast is as high as possible.

***Figure Three** :- Luminance is an objective experience*
***Figure Four** :- Brightness is a subjective experience*
***Figure Five** :- Minimum character details for legibility*

***Figure Six** :- Recommended viewing angle*

Thus, the method of lighting and the layout is more important than lighting levels.
Luminance and brightness are not the same thing: Luminance - is the measured objective quality. Brightness - is the subjective experience.
A car headlamp at night is very bright, but not in daylight, yet its luminance is the same. Only the brightness (which is subjective) has changed. Brightness is affected by adaptation level and should not be confused with luminance.

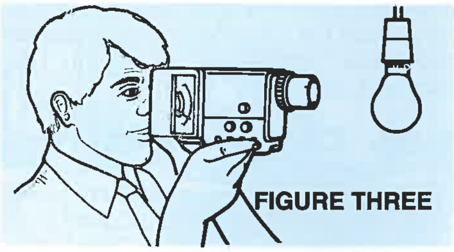


FIGURE THREE

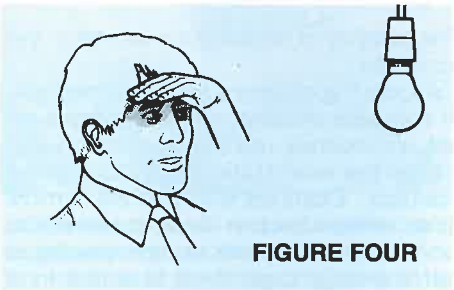


FIGURE FOUR

DISABILITY GLARE

A bright source in the field of view causes disability glare. Light is scattered in the eye and degrades the effective contrast of the image in the optical system - the result is we cannot see as well. When looking at a particular task, any areas which are in the field of view and which are significantly brighter or darker than the task will reduce our ability to see because the brightness range is too great. Our eyes can only adapt to the average brightness in the field of view.

ADAPTATION

We also take time to adapt to different levels. If the luminance we see when we look up is different from when we look at a display, we will have to keep re-adapting - even if only slightly. This will impair our vision, and result in visual fatigue.

COLOUR CONTRAST

Finally a colour difference will help us to differentiate two objects. The effect is very weak unless there is also a luminance change; if an object is difficult to see, changing its colour will not improve matters much unless the luminance contrast also changes. However, when an object is clearly visible, colour can then be used to provide extra information. Do not let salesmen convince you that this or that colour is "better" to look at. Size and luminance contrast are the key factors and some coloured displays may provide improved luminance contrast.
In addition to reading the display - there are other tasks to consider such as typing, reading and transcribing text, using the telephone and so on. Reading poor quality text, or pencil writing may, for example, be very difficult.

GENERAL ADVICE

The Interior Lighting Code of the Chartered Institute of Building Services Engineers is very helpful and gives clear advice. A dark ceiling, for example is oppressive and makes the luminaires distracting and uncomfortable - the discomfort glare will not be acceptable if demanding tasks occur. Insufficient light on the walls and ceiling may be dramatic, but it is not a good working environment. It causes adaptation problems. Low brightness louvres tend to put all their light on the floor and desks. The ceiling is, therefore, dark and only receives light reflected back from the floor or desktop.This maybe oppressive unless it is compensated for in the design of the interior decor.

DIAGNOSING PROBLEMS

If something is wrong with a workstation then 4 symptoms may help with the diagnosis.
Occular Symptoms - complaints of eye discomfort - burning, itching, soreness.
Visual Symptoms - complaints about difficulty in seeing, blurred vision, difficult focusing.
Systemic Symptoms - general complaints - headaches, backaches, fatigue, even indigestion.
Behavioural Symptoms - the operator may not complain - he or she may not even realise there is a problem - but modify the equipment or the way of working. Perhaps a bit of cardboard is used as a hood on the screen, lights are turned off, or an awkward posture is adopted.
The cause can be the visual display unit itself. The environment and the position of the VDT in it. The Operator. Or often, a combination of two or three of the above.

REQUIREMENTS - EQUIPMENT

1 The image in the display needs to be clear. Can you distinguish an O from Q or an a from s ?
2 The image needs to be stable, with no flicker, jitter or drift.
3 Good quality characters should be available. Cramming too many character positions on too small a screen tempts trouble.
4 The luminance and contrast should be capable of adjustment to suit conditions.

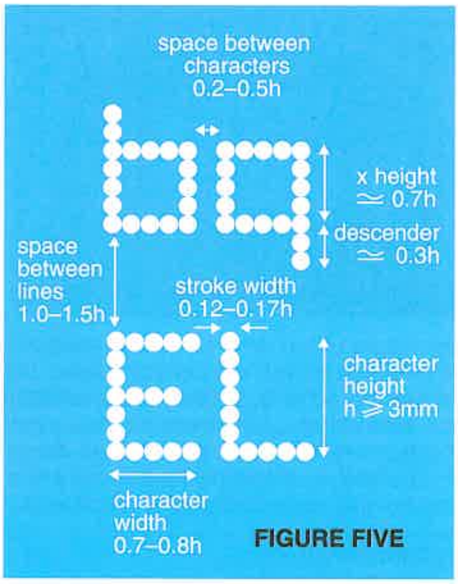


FIGURE FIVE

5 The keyboard should be separate from the screen, and the screen should be adjustable for angle of twist and tilt so that the operator can view the screen at right angles to its surface. It is most comfortable if the screen is lowered and tilted so that it is viewed at about 30 degrees below the horizontal.

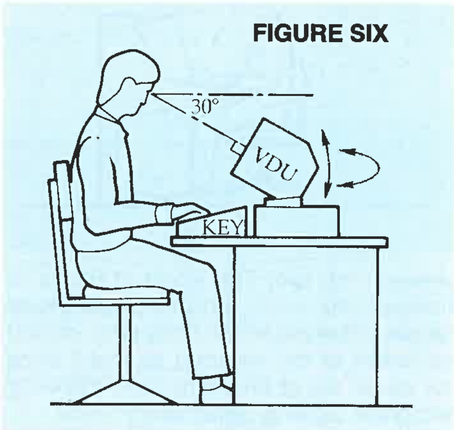


FIGURE SIX

Bad posture, which results from poor positioning and adjustment of equipment, is a common problem, and a major cause of fatigue, backaches and headaches.
6 To avoid adaptation problems the surround to the VDT and keyboard should be of medium reflectance and certainly not black or 'fashionable' dark brown ! It also should be matt to avoid bright reflections.
7 A widespread problem is reflections of lighting or windows in the display. Most people understand that such reflections degrade the image. They can, in fact, degrade the contrast, cause distraction and give false information about the focusing distance for the eyes.

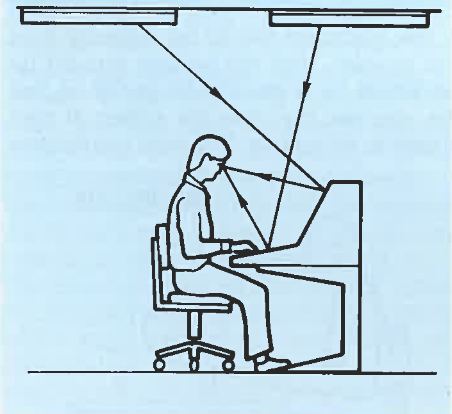
At the top of the page is a fine example of reflected images from light fittings in screen and at the foot of the page reflections in keys.
***Figure Seven** :- Prediction of viewing reflections.*

Sovereign Leasing, in Manchester fully illustrates how the use of up to date VDT lighting equipment can ensure excellent working conditions. The company is systematically replacing 1200mm x 600mm 3 lamp switchstart troffer fittings using general purpose cross blade louvres (shown below). The new 1200mm x 300mm 2 lamp fittings use Categoty 2 VDT reflectors thus ensuring glare free lighting (see facing page). The use of high frequency electronic ballasts also provides flicker free lighting and high efficiency.

It follows that the aim must be to reduce the luminance of the reflected image but

the nature of the reflection is as important. A reflected image with sharp edges will trigger the edge detection mechanisms in the brain and will distract the operator. Furthermore, because the reflected image is at a different focal distance from the screen, the focus of the eyes will alternate

FIGURE SEVEN



between the two. The effect of this is to increase distraction and to cause visual fatigue. The important point is to control the nature of the reflection so that it does not cause visual problems. See following section on Lighting Systems.
8 Reflections also occur in keyboards. Keys are normally dished and will become shiny with finger grease. They will, therefore, reflect images which mask the legends printed in the keytops. Keys must be matt, cleanable and regularly cleaned.
9 Where documents must be read, a document holder in the same plane and at

the same distance as the screen is an essential and comparatively low cost investment.
10 To see the screen, the less illumination on it from the lighting the better, but to see notes, and so on, the more the better. The result is a compromise of 300-500 lux on the horizontal which allows notes to be read and VDT's to be seen. A lower level of 150-300 lux should be used in control rooms, for example, where the tasks involve a lower proportion of paperwork and other conventional tasks.

LIGHTING SYSTEMS

The lighting system needs to be either a low luminance system or an uplighter system. This must be done to minimise reflections in the screen and limit discomfort glare.
With low-brightness lighting, the light is directed down with a cut-off to prevent light at angles which would reflect in screens. This also causes a cut off line half way up the walls. This can make the interior seem rather depressing. A further snag is that the VDT operator is brightly lit and is reflected in the screen.
Uplighting, in which light is directed efficiently upwards onto the ceiling, is a good solution. With well designed systems

there are no high luminances or abrupt changes. The environment is ideal for all types of displays. Also the positioning of the uplights is not as critical as for conventional luminaires.
Uplighting, can be highly efficient. It is inexpensive to install, because only a floor supply is needed, and attracts corporation tax relief. However, great care is needed in the design of the optical system of an uplight to ensure that the rate of change of luminance is correct.
The CIBSE Lighting Guide - Areas for Visual Display Terminals (LG 3) which deals with the lighting of visual displays, categorises the degree of light control provided by low-brightness light fittings into three classes: Category 1, Category 2 and Category 3. The lower the number, the more severe the light control.
Each category has a cut-off angle and above this angle the brightness of the light fitting must be controlled to be less than 200 Cd/m^{-2} (candelas per sq. m) The categories are:

Category	Cut off Angle	Luminance Limit
Cat 1	55°	200 Cd/m^{-2}
Cat 2	65°	200 Cd/m^{-2}
Cat 3	75°	200 Cd/m^{-2}

The category of equipment must match the application.
Category 3 applications are the normal type of computer situation, where operators do not continuously use the workstation and where the workstations are to a good standard. Examples would be the terminal at an airline check in desk, a secretarial workstation where the wordprocessing is not the only task, or a terminal in a manager's office. Almost 70% of all workstations will fall into this class.
Category 2 applications are those in which the workstation are continuously used and the work is demanding. Examples would be terminals in an order processing office, wordprocessors in a typing pool or terminals in a design office. Almost 30% of all workstations will fall into this class.
Category 1, as you can tell from the above percentages, is rather unusual. It applies to some of the most severe situations, such as the CAD areas in silicon chip design, some control rooms or certain banking

***Figure Eight** :- General recommendations*

situations where VDT's are at awkward angles. Generally speaking these situations are special cases and include other special

problems which will require attention and expert advice should be used.

Do not think of the fitting categories as an order of merit. As the category number decreases, so does the efficiency. With direct downlighting installations, particularly with Category 1 or 2 luminaires, attention must be paid to other aspects of lighting design and general decor to avoid a 'gloomy' interior appearance resulting from low vertical surface illuminance.

If low-brightness VDT fittings are used then they must have the appropriate category, but correctly designed uplighting is suitable for all categories of use, is efficient and is one of the easiest retrofit solutions.

Just because a room contains a lot of VDT's it does not mean that there must be a serious visibility problem. In the computer room of a major credit card company, rather surprisingly, although there are lots of displays, the visual problem isn't too exacting, because the displays are very legible and are only used for brief periods. At a major travel company, the displays are very legible and are only used for short periods, so most of the rules can be broken without much problem.

DAYLIGHTING

Windows provide an important link with the outside, but are more disruptive than luminaires. The luminance of the sky and exterior surfaces are much higher than luminaires. In front of the operator windows are a glare source and cause disability and discomfort. Behind, they reflect in screens and cause severe loss of contrast, causing severe disability. To the sides, they are less of a problem but they can be distracting and can be a source of discomfort glare or veiling reflections.

Venetian blinds and vertical ribbon blinds are suggested in some recommendations but need to be used with care. They can cause very disruptive regular patterns on the screen. Curtains, or better still, roller blinds are good solutions but may not be liked by the architect.

CONCLUSION

It is also important not to forget the eyesight of the operator - ordinary spectacles may not be satisfactory at the distances involved. The reading distance is greater than normal, and standard prescription reading glasses would be incorrect. Special glasses are often required for the new seeing distances.

The EEC directive requires employers to perform an analysis of workstations in order to evaluate the safety and health conditions that they may cause. This is particularly important regarding eyesight and visual difficulties which have been the main topic in this article, physical problems and the mental stress which inadequate conditions may cause.

The employer must take appropriate measures to remedy these problems.

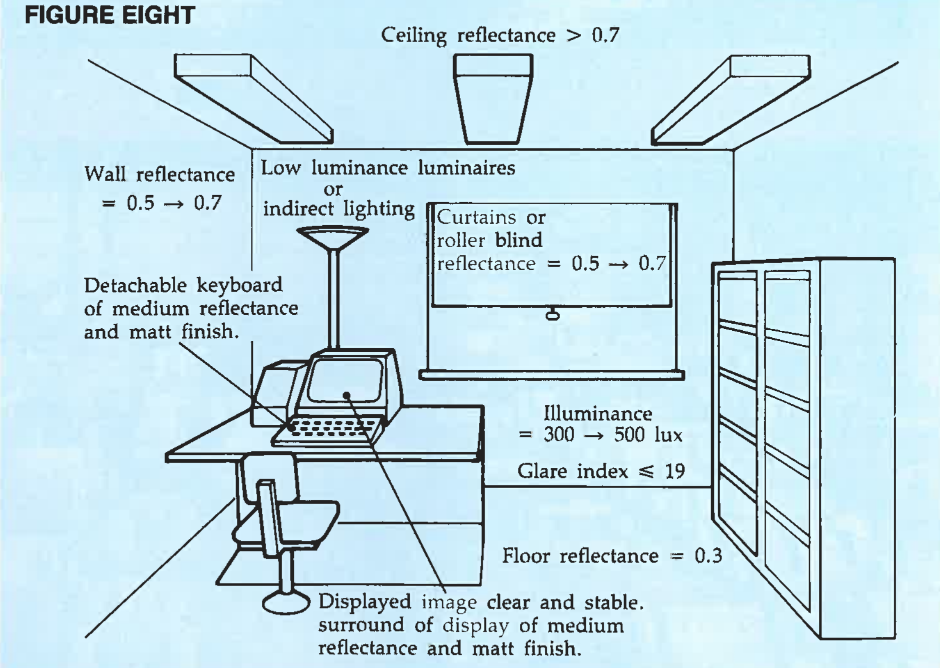
Workers must be informed about these issues and informed about any measures which are taken to comply with the directive.

The work needs to be designed correctly and workers must be given appropriate training and advice. This training must be given before commencing work on a workstation or if it is modified. Work must be structured with breaks or changes in activity to reduce the workload at the screen and periodically interrupt the use of the screen.

These matters are not optional, the employer must do them. Furthermore, some of the judgements call for expert opinion. Please note that in this article it has only been possible to give general guidance. It has not dealt with every situation, or all the requirements of the VDT Directive, nor is it a substitute for expert advice.

Although one display may be similar or even identical to another, the way that it is used will not be. Thus all display problems are different and there is no "magic" solution to good visibility. However, the problems are well understood and sound professional advice is available.

FIGURE EIGHT




SWL 25t
DAVY MORRIS
SWL 25t

MI King, opposite, where the service illuminance has risen 150 per cent and electrical load fallen 33 per cent.

THE EMILAS AWARDS

These days, nothing appeals so much as efficiency and economy, whether it be in the smallest business, the largest conglomerate, the largest public enterprise or the smallest home. Whatever else the 1980's brought, it brought to individuals and leaders alike a sharp appreciation of the value of being cost and waste conscious. The Energy Management in Lighting Awards Scheme (EMILAS) organised by the Lighting Industry Federation fully illustrates the user benefits that can be achieved from installing today's energy efficient lighting products. The awards are "for improving the efficiency of electrical usage for lighting and to encourage good energy management practise for lighting installation". The scheme includes sections for new schemes and the conversion of old industrial and commercial ones.
Last year THORN Lighting installations won two major sections and other schemes were highly commended.

INDUSTRIAL SECTION WINNER

L'Oreal, Llantrisant

L'Oreal manufactures a wide range of beauty products at its recently extended Llantrisant factory. The company is environmentally conscious having been one of the first to eliminate CFC's from aerosols- so it was not surprising that it required a system of lighting controls which maximizes the large quantities of daylight which penetrate, via large rooflights, into the factory. A scheme which reflected the quality of the interior was also called for, to respond to the maxim that all good factories need lighting, not to spot when things go wrong, but to constantly see that everything is going right.
Artificial lighting is provided from 142 twin 58W fluorescent batten fittings with reflectors which are linked, to a state of the art lighting management system.
The lighting has been designed to provide a constant 400 lux. The output from the lamps is adjusted from 25% to 100% according to the amount of natural daylight available to the operators' shifts and other occupancy patterns. Commands are sent to the HF electronic ballasts which control the lamp via micro processors which respond to information received from photocells and programmable clocks.
The system is centrally controlled by a computer system. This is expected to be linked into the BMS system which controls the whole Llantrisant site, which will generate even greater savings.
L'Oreal's factory management are particularly pleased with the system which

is achieving an efficiency of 2.3/m²/100 lux. The system is adjustable and can be overridden from a wall mounted trimming device. In addition, should the use of the area need reconfiguring at any time, the lighting installation is flexible enough to allow for re-programming.

INDUSTRIAL SECTION
HIGHLY COMMENDED

British Coal, Machine Service Division, Tursdale, Durham

The Centre refurbishes electric motors, ventilation fans, panel switches and pumps for collieries throughout the UK and also assembles coal face installations to ensure compatibility before transporting underground.
The plant's engineers at Tursdale decided to replace the dated and inefficient lighting system comprising a mixture of old style 310W high pressure sodium lamps and

500W incandescent lamps. The installed lighting load, at 90.1kW, was high and the lighting only provided an illuminance of 200 lux.The new system, involved a point for point replacement with 400W high pressure sodium lamps. This halved the load to 45.8kW and increased the illuminance 150% to 500 lux. Efficiency has dramatically improved from 7.4 to 0.9 w/m²/100 lux. In addition, the new lighting requires substantially less maintenance.
At Tursdale the electrical tariff has now been lowered. This has been possible because of the reduced lighting load, together with changes in the working pattern and times when load tests on the refurbished electric motors is done. This enables a move from DMLV option A to DMLV option B which means an additional saving of 15% on electricity charges.
The company anticipates that the energy saving will pay for the new scheme in 18 months.

INDUSTRIAL SECTION
HIGHLY COMMENDED

MI King,Washington, Tyne & Wear

This company which employs twelve people manufactures steel blanks which are sold on to customers like Nissan for conversion into components. The business was created in 1989 as joint venture between Mitsui and William King - long established Midlands based steel stockholders.
Quality is M I King's watchword, both in the materials they hold, the items they process and the operations which they use within their factory unit. So when it was decided to upgrade the lighting, it had to achieve the same standards.
Fifty seven high bay luminaires from THORN Lighting with 400W high pressure sodium lamps replaced fifty one aged 700W mercury reflector lamps in fittings with poor, patchy distribution. The new scheme has reduced the installed loading by 33%, from 36.7kW to 24.6kW, but lighting levels have improved by 150% to 300 lux. This was vital as the company wanted to improve the visual ability of the workforce to inspect processes at every stage of operation. Efficiency has improved from 4.7 to 1.3W/m²/100 lux.
Employees have also noticed that the new lighting is "brighter and warmer" as a result of the change over from the cold, white mercury to the golden light of SON.

COMMERCIAL SECTION WINNER

THORN Lighting, Borehamwood

This international head office uses a state of the art lighting management system.

The new lighting replaced an original system which provided an excessive 900 lux with an installed load of 50.2 kW. The lighting management system has reduced this to a mere 12.8 kW - a 74% energy saving. Efficiency has likewise improved from 2.7 to 1.9 W/m^2/100 lux.

The overriding architectural feature of this three storey, glass-clad building is the amount of daylight penetration particularly through the central atrium.

The aim of the lighting design was to provide an average of 500 lux at desk level. The high levels of daylight, combined with the luminaires, often provides more than sufficient to comply with this. The lighting system optimises this situation.

Throughout the general office areas 600mm square fully recessed modular fluorescents with low brightness 16 cell louvre attachments were selected. The luminaires incorporate high frequency (HF) electronic control gear which is dimmable and operates 2 x 2L 40W 3500K linear compact fluorescent lamps.

The HF ballasts dim down or switch off the artificial lighting on the basis of signals received from a series of micro processors which respond to information from photocells, wall switches and mainsborne signals which reflect the building's occupancy patterns. The system is centrally controlled.

Some smaller areas are designated to 'stand alone' intelligent fittings with inbuilt photocell and presence detection units. These fittings respond to daylight and switch off when no one is working within their zone.

COMMERCIAL SECTION
HIGHLY COMMENDED

Peugot Talbot Motor Company, Stoke, Coventry

Peugeot Talbot's Headquarters is now located in a newly refurbished building on the huge Coventry site. Refurbishment of Aldermoor House included the replacement of a lighting scheme installed in the '60's' with an electrical loading of over 92 kW.

The new system uses high performance recessed modular fluorescent fittings, each of which incorporates three 36W tubes. The luminaires are fitted with low brightness (Category 2) louvres to inhibit glare in VDT screens, and electronic starting devices to

ensure instant starting and help maintain the life of the lamps.

The new offices now enjoy a 63% reduction in the lighting load but the illuminance levels have improved 54% - 350 lux. Overall, efficiency has improved six fold from 6.7 to 1.6W/m^2/100 lux.

COMMERCIAL SECTION
HIGHLY COMMENDED

South Glamorgan County Council's Llanederyn High School, Cardiff

Llanederyn High School gymnasium, like many of its type, was lit with an ageing scheme which used twenty eight 500W incandescent light bulbs. Following an initiative by the local authority's energy conservation unit, this school has now benefited from a more appropriate lighting scheme which uses 12 low bay fittings with 250W high pressure sodium (SON) lamps.

As a result, the installed lighting load is 75% lower (a dramatic fall from 14kW to 3.3kW) while lighting levels have doubled from 200 to 400 lux. The overall efficiency of the lighting has dramatically improved from 25 to 3.02W/m^2/100 lux. Added savings are achieved from photocells which switch the lights off when there is enough

natural light. A sensor has also been fitted which turns the lights on when someone enters the gym and turns them off when it has been empty for a set period.

Teachers and pupils are extremely happy with the new lighting which is not only brighter but safer. The school governors and local authority are pleased with the energy savings and expect the new scheme to have paid for itself within eighteen months.

ENERGY AND LIGHTING

In the UK lighting accounts for some 16 per cent of electricity consumption. The widespread application of energy efficient lighting products/systems could, in overall terms, reduce UK electricity demand by some 8 per cent.

The cost elements making up the total cost of lighting provision are:-

- Capital cost - equipment
- Capital cost - installation (labour and materials)
- Annual cost - maintenance (cleaning/labour)
- Electricity cost

Examination of the annual cost of lighting (including an annual apportionment of 20 per cent of the capital expenditure) shows that for the great majority of lighting installations electrical energy is the major cost element.

The design of lighting installations to a given standard but with minimum energy use (maximum cost effectiveness) requires attention to six key design factors.

- Use of most efficient light sources suitable
- Effective use of lamp light output (luminaire performance)
- Good maintenance
- Well designed lighting schemes
- Control of switching operation and installation usage.
- Taking account of the effect of surrounding decor.

ENERGY UTILISATION APPRAISAL OF LIGHTING INSTALLATIONS

The general relationship between energy effectiveness and cost effectiveness requires lighting installations to use energy efficiently. Therefore both existing lighting installations and proposed designs need to be appraised in a manner which determines energy effectiveness. The Installed Load Ratio (ILR) Method is simple and easy to apply for all lighting applications designed for average horizontal illuminance.

The electrical energy used by a lighting installation is determined by:-

(a) the installed electrical load (kW)

(b) the hours of operation (usage)

The usage depends upon the duration of occupation of premises or areas and the ability to control the installation according to these requirements but, for any given usage, the energy consumption is directly related to the installed electrical load (kW) which can therefore be used on a basis for assessing energy effectiveness.

INSTALLED LOAD RATIO METHOD

This requires:

(1) a measure of the actual performance achieved (or planned for a new installation) in terms of the electrical load (Watts) required to provide 100 lux of horizontal illuminance over each sq. m of area (W/m²/100 lux);

(2) a target performance expressed in the same terms, ie W/m²/100 lux. The target performance is the best possible (ie minimum installed load for required lighting result) and is based upon a practical energy effective design approach and good lighting practice (see Table 1).

The energy efficiency of a lighting installation can then be assessed by comparing the actual W/m²/100 lux with the appropriate target value and expressing this as a ratio.

$$ILR = \frac{\text{Target performance W/m}^2\text{/100 lux}}{\text{Actual performance W/m}^2\text{/100 lux}}$$

The objective for any lighting installation must be the achievement of an ILR which approaches 1.0. This is common for all general lighting situations irrespective of the illuminance level achieved or designed for.

Poor maintenance of existing lighting installations frequently results in an efficiency loss which cannot be eliminated by cleaning because of permanent damage to and/or deterioration of reflecting surfaces and/or prismatic controllers etc in the luminaires. Therefore the most suitable method of appraising an existing lighting installation is to measure the average horizontal illuminance with a light meter, determine the installed load, measure the area, calculate W/m²/100 lux and compare with the appropriate target value to obtain the ILR. The calculated ILR may then be assessed by using Table 2 as a guide to determine if a cost-effective conversion is possible or not.

The results of EMILAS as detailed, clearly indicate the substantial scope for saving energy. The accompanying table 3 shows a selection of commended entrants with typical savings. There are many examples of refurbishment schemes halving the electrical load and at the same time giving a considerable gain in illuminance.

Where the refurbishment of lighting installations in the interests of energy saving is planned, account should be taken of any adverse effect on energy requirements for heating. Where air-conditioning or refrigeration systems are in use, any energy saving measure taken in respect of lighting may also generate additional savings in air-conditioning services.

Further guidance on energy management in lighting is provided in the LIF's 'Energy Manager's Lighting Handbook'

TABLE 1

Installed load
Target performances (interior lighting) in Watts/m²/100 lux

Room index	Commercial offices, retail premises etc. Standard or good colour rendering CRI Ra 50-85	Industrial Standard or good colour rendering CRI Ra 50-85	Industrial non-critical colour rendering			
			300 lux		500 lux	
			H_m<6m	H_m>6m	H_m<4.5m	H_m>4.5m
5	1.64	1.54	1.48	1.28	1.48	1.28
4	1.68	1.58	1.51	1.30	1.51	1.30
3	1.77	1.64	1.56	1.34	1.56	1.34
2.5	1.89	1.70	1.58	1.37	1.58	1.37
2.0	1.96	1.80	1.64	1.42	1.64	1.42
1.5	2.04	1.96	1.72	1.50	1.72	1.50
1.25	2.15	3.20	1.79	1.56	1.79	1.56
1.0	2.25	2.31	1.89	1.68	1.89	1.68
0.75	2.35	2.49	2.07	1.85	2.07	1.85

Note

(i) These targets are based upon high interior surface reflectance factors and good maintenance programmes

(ii) Room index = $\frac{LxW}{H_m(L+W)}$

where L is length of room. W is width and H_m the mounting height of luminaires above the working plane

TABLE 2

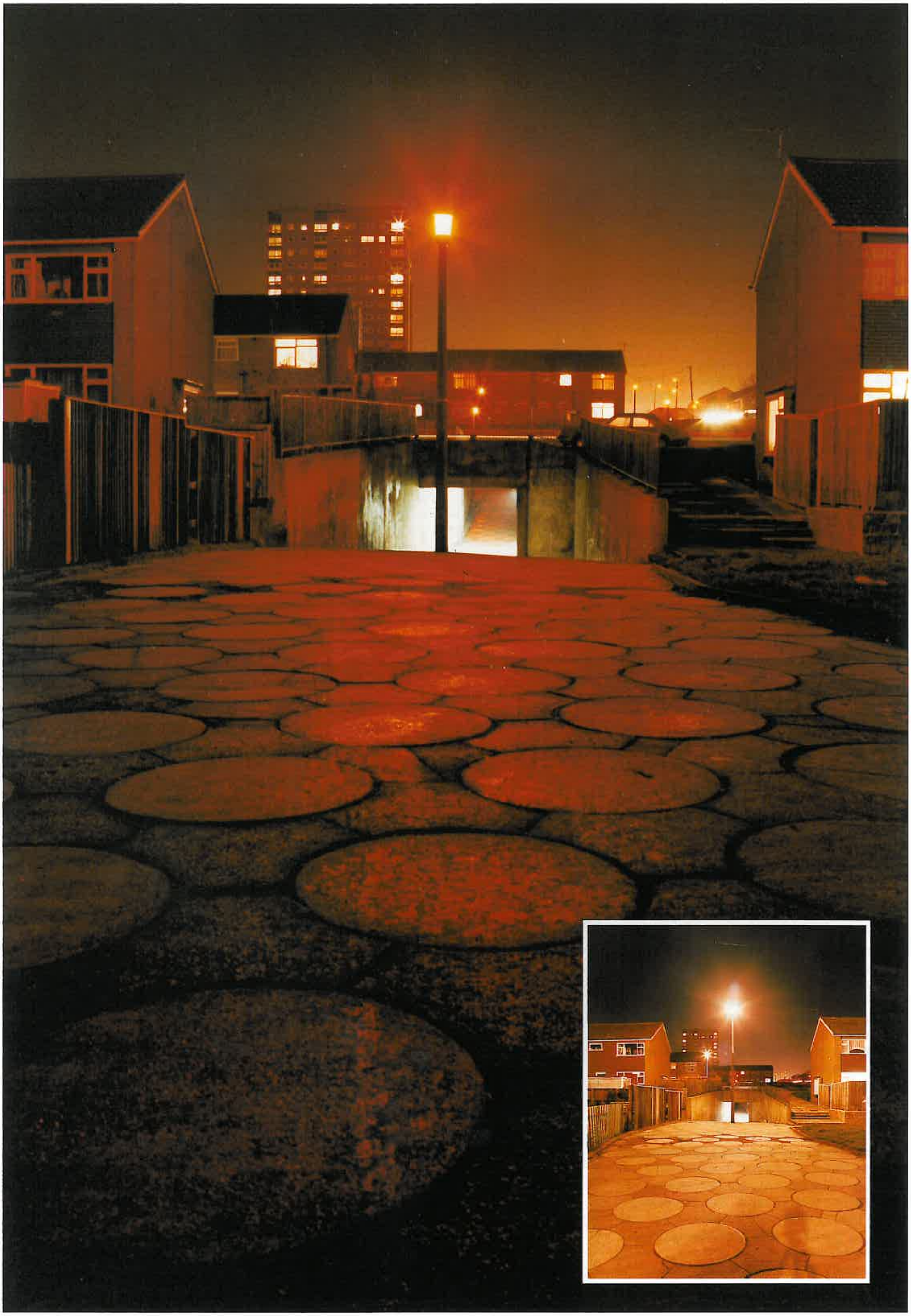
Assessment of existing installations

ILR	Assessment	Cost-effective conversion?
0.75 or over	Reasonable-good	Unlikely
0.5-0.75	Review suggested	Probably-possibly
0.5 or below	Poor	Almost certain

TABLE 3

Selection of entrants from EMILAS '90 showing typical savings

User	Type of Location	Lighting Type	Reduction in Lighting Load	Improvement in Illuminance
National Power, Rugeley	Control Room	Uplights (2L36W)	62%	140%
Leicester City Council	Office	Recessed (HF) fluorescent Cat 2 louvres	52%	38%
R.S Components, Corby	Warehouse	Fluorescent Racklighting HF ballasts	31%	312%
Fleetwood Caravans	Assembly	250W & 150W SON-DL Low bays	36%	161%
Kerrier District Council	Sports Hall	(HF) Fluorescent	39%	67%
IMI Range Ltd. Cheshire	Production	150W SON-T Low bays	(8%)	400%
British Aerospace, Kingston	Assembly	400W SON-DL High bays	16%	67%



Shown are two "before and after" views of the Swarcliffe - Stanks area in Leeds.

STREET LIGHTING AND COMMUNITY SAFETY -THE LEEDS PROJECT

The illumination of urban areas can no longer be treated in isolation. Successfully and sympathetically incorporated into its environment, lighting has enormous potential to establish the mood of any area. It reinforces the individual's feeling of safety and security; it enhances the achievements of architecture, both past and present; it vanquishes the twilight area of our open spaces and influences the activities of residents.

The effects of urban lighting are so important that illumination should be one of the main elements in any residential area. Yet in the fight against urban decay, lighting's role is still hugely under-represented. Fortunately this is being addressed by campaigns like that which the all party British Parliamentary Lighting Group is currently running and in October 1991 they announced the findings of six new research projects. One of the largest and most comprehensive projects took place in Leeds and is worthy of discussion.

The study by Tom Burden and Liam Murphy of the Policy Research Unit at Leeds Polytechnic called 'Street Lighting - Community Safety and the Local Environment' set out to examine the extents to which improved street lighting could enhance the quality of the environment and bring about changes in attitudes and behaviour which would improve community safety and the quality of life for residents of the area involved. The findings clearly show that better lighting does modify the perception and behaviour of local residents.

PLANNING AND DESIGN

The planning for the project began in early 1990 and involved a controlled 'before' and 'after' survey of the impact of improved street lighting on peoples perceptions of the environment and community safety. The area chosen for the project was the Swarcliffe - Stanks area in Leeds.

The research work was financed jointly by Holophane (Europe) plc and Leeds City Council and employed a multi-agency approach involving the academics, local councillors, the City Lighting Department, the police and industry, with THORN lanterns being used throughout the re-lighting.

DESCRIPTION OF THE SITE

Swarcliffe is situated some 5 miles North East of the City. It is a large, 800 dwellings, 1960's built estate and was chosen because it was largely pedestrianised, contained community facilities including public houses and importantly had a very high crime rate. For example, over 50% of households had suffered some damage to household property over the previous year and over 70% had a vehicle tampered with or damaged. The majority of dwellings are low housing except for four tower blocks within the area of study. Most of the households interviewed lay within a sector bordered by Stanks Drive, Stanks Lane North and Swarcliffe Avenue. This enclosed area has no through traffic routes and is a network of cul-de-sacs and service roads with an extensive pattern of internal footpaths.

LIGHTING BEFORE IMPROVEMENT

The lighting comprised of approximately 320 - 35W SOX lanterns, both side entry and post top versions. Mounting height for the concrete columns was 15ft and the spacing between columns varies from 27m to 39m. The whole site was gloomy and dull with many dark patches and a failure in the most part to meet even the least demanding requirements of BS5489 Part 3. In fact 21% of respondents identified poor lighting as a 'big problem' in the area.

LIGHTING AFTER IMPROVEMENT

Due to economic constraints it was decided to convert the existing columns to 6m mounting heights rather than change the column positions. Each unit was fitted with a steel extension sleeve and lanterns using 70W SONXL lamps were installed. After re-lighting the requirements of the BS5489 Part 3 code of practice for lighting residential roads (Category 3/2) are substantially met over the area. Good uniformity has been achieved and more light provided resulting in less areas of shadow and good colour rendition. This change from SOX to SON is in line with part 3, where high pressure sodium is the preferred light source for areas in which pedestrian activities predominate or where the crime risk has to be considered. The choice of light source was also important to the respondents of the survey. There was a clear preference (59%) for the white light which can be interpreted as a desire for SON where crime is a concern.

THE STREET SURVEY

The Swarcliffe research methodology involved using interview schedules, recorded interviews, questionnaires, observation and official police statistics. The topics covered included community safety and the local environment, crime and fear of crime. Trained interviewers were used. In the main the research concentrated on local residents who were questioned regarding their personal experiences before and after the new lighting was installed. The interviews were conducted in two phases, 173 households (22% of the total households in the area) were spoken to in Phase One and 166 in Phase 2 with 84% of those interviewed originally being re-interviewed at the second stage.

KEY FINDINGS

The improved street lighting was viewed as a big improvement to the local environment. It also increased the feeling of security: 44% of people felt safer in the streets around their home and 23% felt safer in their own homes. The impact on the perceived safety of women was substantial. There was a reduction of 29% in those who thought women were at risk from sexual assault. The willingness of women to go out alone went up, and their fear of particular places and types of people was reduced.
The largest single improvement was a 31% reduction in worry about having a car stolen or damaged, itself viewed as one of the major problems of the area. Overall the research found a substantial increase in the feeling of personal security and some evidence of a reduction in the restrictions imposed on people by their concerns about crime.

THE REALITY OF THE PROBLEM OF CRIME AND FEAR

Before the improvement in the street lighting a substantial proportion of people (42%) said being afraid to go out at night is a 'big problem' and another 34% saw it as a 'bit of a problem'. This is evidence that the night time environment is identified with special dangers and problems.
The research team asked people whether they regularly walked along the street outside their home. 29% avoided the streets during the hours of darkness. The proportion of men who always felt able to go out was 72% while for women the figure was 29%. 43% of residents felt unsafe because of the possibility of crime against them. Women (53%) were twice as likely as men (27%) to feel unsafe.
During the hours of darkness numbers of people are also deterred from undertaking activities that they would like to do. For example, 22% were inhibited from using public transport as much as they would like.
The threat to homes and belongings on household property is indicated by evidence from those interviewed of 51 break-ins and attempts and 35 reports of something stolen from outside. Crimes against peoples' homes are viewed as especially disturbing even when the material value of the loss is small or non-existent. These offences are a serious intrusion into privacy and personal life and their psychological effects are often close to those of violence.
Offences committed against vehicles were reported by a majority of households owning a vehicle. The insecurity of vehicles is an outstanding feature of the area. These offences overwhelmingly involved damage and tampering (59%) rather than theft which 'only' affected 9% of the car owning households. The figures also show that crimes involving vehicles are particularly likely to take place at night.

THE IMPACT OF NEW LIGHTING

People's (%) Evaluation of the 'Old' Lighting

	Yes	No
Too dull	66	35
Too bright	5	95
Unevenly spaced	63	37
Well maintained	45	56
Badly maintained	57	43
Satisfactory	52	48
Create shadows/glare	51	49
No views	27	73

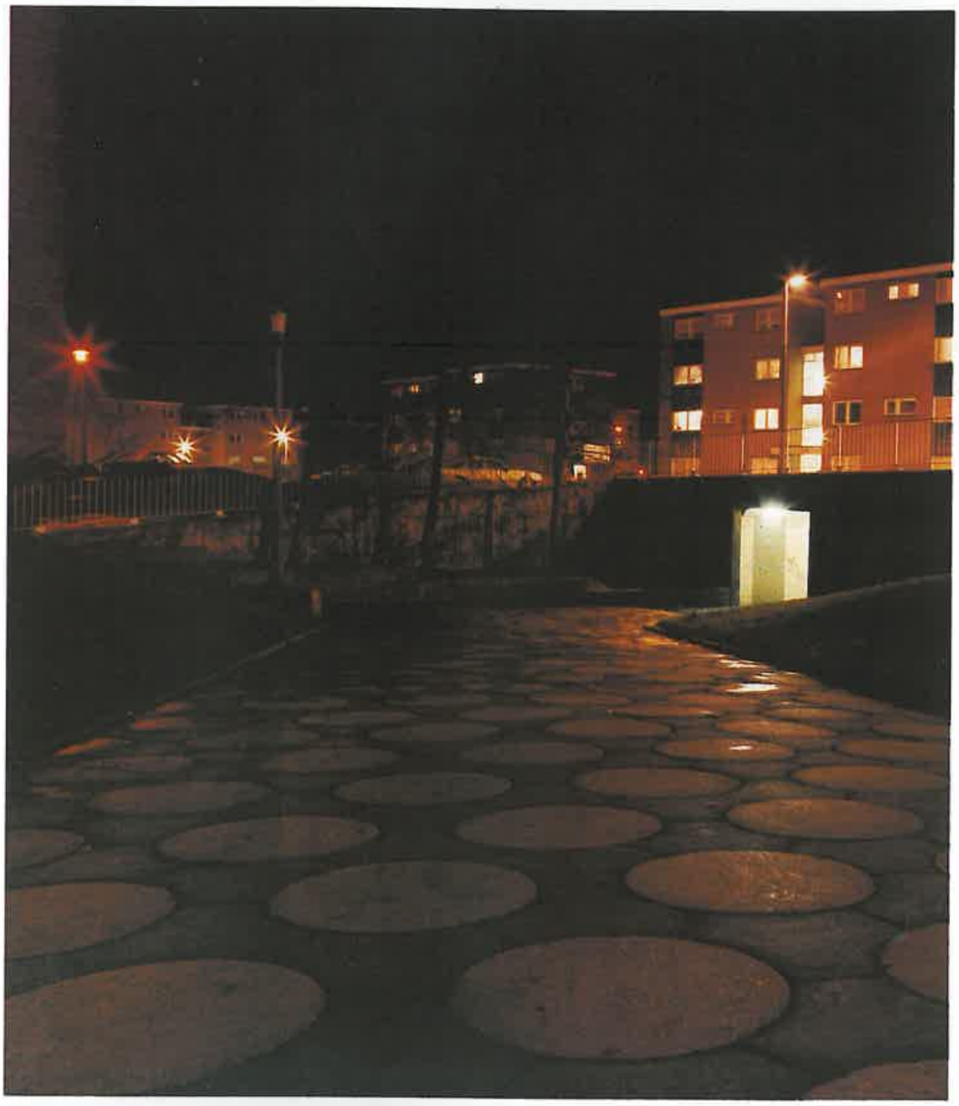
After the installation of the new lighting 85% of the residents said they had noticed a change and 95% of these thought it was brighter. Over 60% of the respondents thought that the 'look of the area' had been improved. This is important. Part of feeling at home in a neighbourhood is the sense that it looks and feels an attractive place. Almost three quarters of the total sample felt that the lighting made it easier to recognise people. This is a very important finding because it may increase the sense of security felt by residents. Friendly faces can be more easily recognised and so can unfriendly ones. It also helps in identifying people engaged in criminal and anti-social behaviour.

People (%) worried 'a lot' or 'quite a bit' about...

	Pre	Post	Change
Home broken into and something stolen	62	56	-10
Being robbed in the street	29	32	+10
Being attacked in the street	36	35	-3
Being insulted/ pestered in the street	29	31	+6
Home damaged by vandals	57	54	-5
Having your car stolen or damaged	54	37	-31
Women only. Being sexually assaulted/ raped	35	29	-17

Following re-lighting there were small increases in the numbers concerned about physical violence against them in the street. However, the biggest change involved a reduction in the numbers worried about their car being stolen or damaged. This was cut by nearly a third (31%) after the re-lighting.

The Swarcliffe area before and after re-lighting.



HOW TO REDUCE CRIME ? RESIDENTS' VIEWS

Before and after the relighting residents were asked what they thought would do most to reduce crime in the area. The figures show that many residents felt that better lighting has a significant role to play in crime prevention. More police on foot patrol remains the most widely supported means of reducing crime in the community. Tom Burden, Project Manager concluded:- "The reactions of local people to the new lighting were very favourable. It definitely helps to reduce people's fears about crime and increases their feeling of security. Many members of vulnerable groups, such as women and the elderly, now have more confidence to go out at night. Getting more people out on the streets after dark should also have a knock-on effect in making them safer for everyone. There's no doubt that improving street lighting has considerable merits as a means of increasing community safety".

Changed Feeling of Safety after Re-Lighting (% of people)

	In Streets around home	In home
Increased	55	33
Decreased	1	2
No effect	43	65

There is also evidence in the report that recorded crime in the two months after the relighting was less than would otherwise have been expected.

THE IMPACT OF IMPROVED STREET LIGHTING ON WOMEN

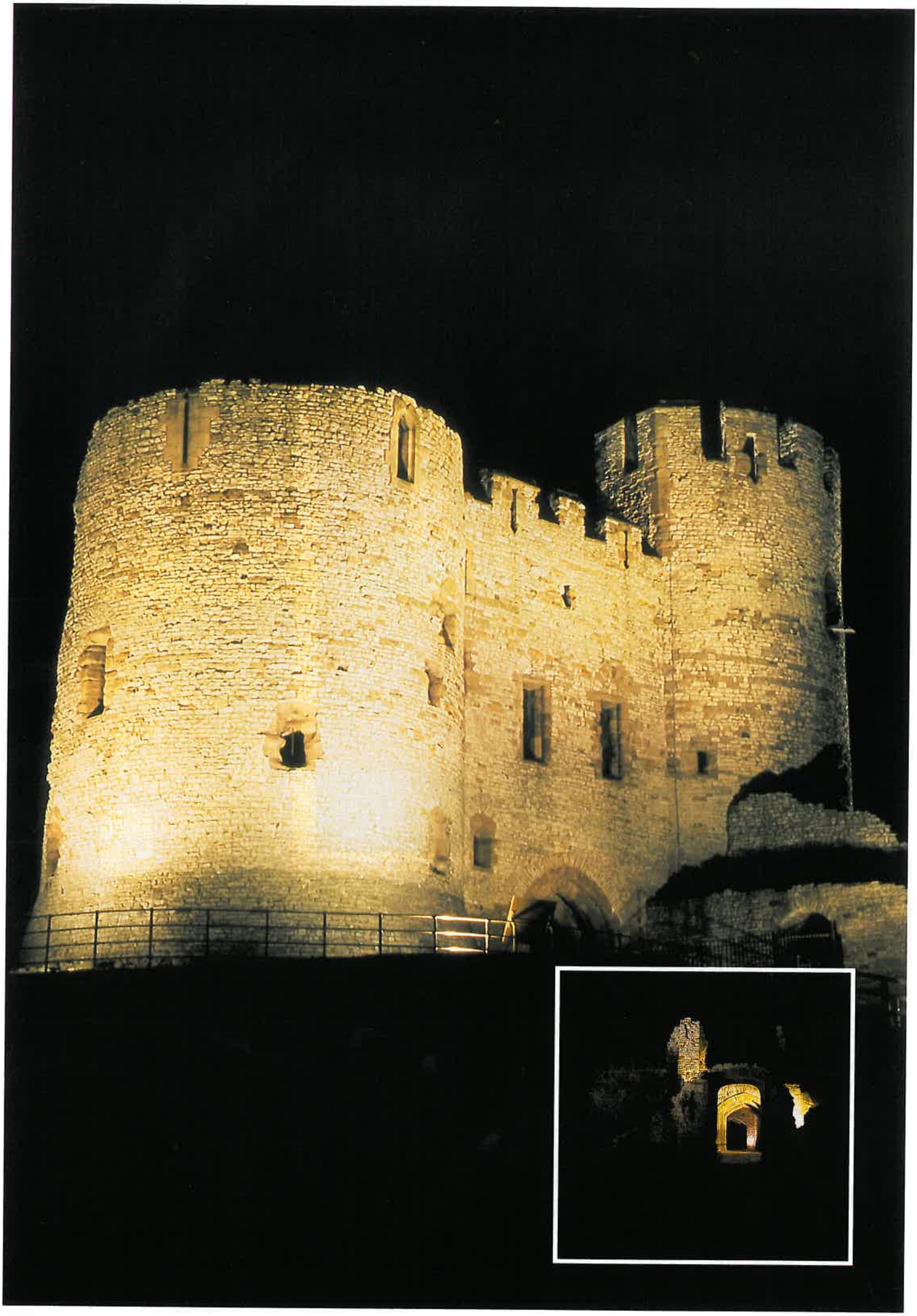
The number of women worried about being sexually assaulted or raped was cut by 10% following the relighting of the area. The proportion of people who felt that women were at risk also fell from 68% to 48% after the relighting.
There are substantial alterations in the willingness of women to go out after dark. Not only are they more willing to go out but they are less concerned to avoid particular types of people or particular areas.

Adjustment of Behaviour of Women Pre and Post Re-Lighting (%)

	Pre %	Post %	Reduction %
Stay in when you would like to go out	34	7	79
Avoid walking near certain of people	47	27	43
Stay away from certain streets	46	24	48
Go out accompanied, not alone	69	49	29
Take car/taxi rather than walk	53	42	21
Avoid using buses	15	7	53

Recommended Methods of Crime Prevention (%)

	Pre	Post
More police on foot patrol	82	84
Better, brighter street lighting	43	32
More leisure facilities for young people	42	55
More Neighbourhood Watch Schemes	37	33
Harsher sentences for convicted offenders	36	43
Stronger locks on doors and windows	23	33



A dramatic view of Dudley Castle. The entrance interior (inset) is uplit by floor-mounted tungsten halogen lamps to soften the entrances appearance.
Below :- *can be seen the luminaire mounting positions and cable routing distribution. Diagram courtesy of Electrical Design Magazine.*

NEW INSTALLATIONS

NIGHTS OF OLD

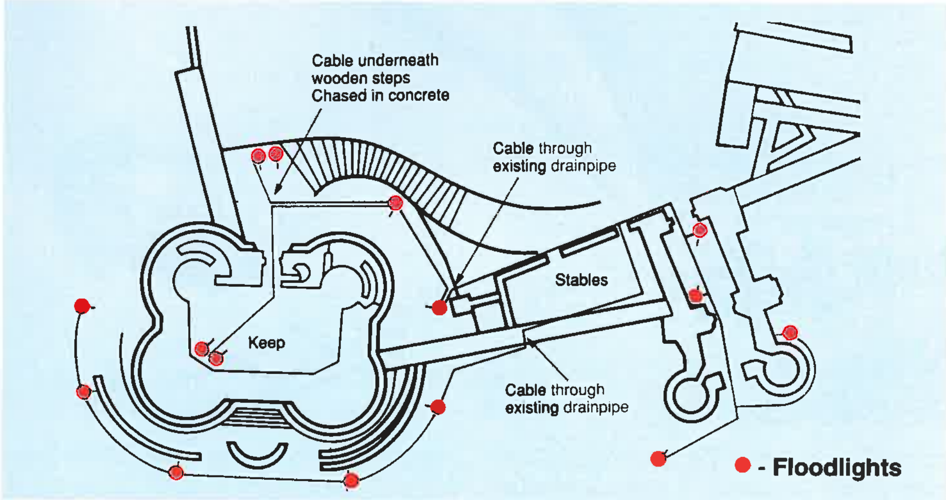
Civil War, treason and fire have all shaped the long and violent life of Dudley Castle, standing over its Black Country domain and now the centrepiece of the town's zoo.
Five years ago the history of the castle looked like following one of its owners - John Dudley, protagonist of Lady Jane Grey's ill-fated ascent to the throne in 1553 and executed for his ambitions - by coming to a foreshortened conclusion. The buildings, diminished during Civil War to prevent the castle being re-used as a fortress defence and ravaged by fire in 1750, fell into a third phase of decline when, in the early 1980's, the castle was declared structurally unsound. The Council stepped in, bought the land leasehold and placed the castle buildings under the auspices of the Dudley Zoo Development Trust.
An eight year, £500,000 appeal and the work of keen archaeologists and locals has saved the site and the first stage of a floodlighting scheme has been completed to give the castle a high profile by night.

DESIGN CONSTRAINTS

The floodlighting project features the illumination of the keep and triple gateway. The lighting designers found progress a matter of compromise because of some very severe design constraints particularly English Heritage's requirements that there were to be no fixings attached to, or holes drilled into, the castle walls.
The method favoured by English Heritage of placing the floodlights some distance from the castle itself was not practicable because a perimeter wall would have obstructed light at much of the castle's lower levels. The solution was to recess floodlights into the ground at near points to the walls and so 1kW metal halide CSI lamps were chosen for their compact size and different optical lenses were used to achieve optimum control of the light.
The eventual positioning of the luminaires was still a compromise between designer and historian while the mounting of the luminaires in stone, vandal proof housings has kept their daytime appearance as discreet as possible.

THE LIGHTING EFFECTS

The metal halide floodlights produce around 100 lux at the castle walls and with their good colour rendition properties give an effect which was felt to be both true and enhancing to the appearance of the castle stone.
Two cannon positions standing proud of the keep are each picked out by pools of light from two 400W MBIF floodlights. Another CSI flood washes across the entrance to the triple gateway, away to the right, creating shadowing and interest as the light crosses the arched frame at an angle. On the other side of the entrance a 250W high pressure sodium projector picks out the entrance way and provides a more subdued effect.
Inside, the gateway is uplit by two floor-mounted 500W tungsten halogen floods, diametrically opposite, used to soften the entrance's appearance and create a glow when viewed from outside.
Moving through and into the castle courtyard brings the visitor to the more modern buildings at the site. Sir William Sharrington, a pioneer of the Italian phase of the Renaissance in England, carried out most of the building work within the inner areas for the Duke of Northumberland. These buildings remain unlit but will form the second phase of the floodlighting scheme when funds become available.
The rear of the keep is also picked out by CSI floodlights again housed in recessed stone pits. On this side, between the triple gateway and keep, are what were once stables. The building was originally at two levels, with the horses below and the knights sleeping above using the heat from the horses to keep warm. It now hosts the power distribution point, taken from one of two substations installed for an earlier, unrelated project.
Power distribution routing suffered from similar design constraints to the lighting. No holes could be cut through castle walls and so eventually the cabling was run through existing drain holes. Any trenches that needed to be dug were excavated by archaeologists; including digging up cobblestones to run cables to the fittings inside the triple gateway.



CONCLUDING THOUGHTS

The night-time appearance of the castle has received universal praise from the local populace. Although they might have been less impressed had they suffered the fate of their predecessors under the ruthless baron John de Somerey, for he required that the men from the surrounding environs pay either protection money or give physical help for improvements to the castle.

LIGHT IN THE FAST LANE

Lighting a bobsleigh track presents a number of technical problems. These include potential glare on the ice, the bends, curves and inclines of the track; the need to choose mounting positions carefully so that the bob drivers are not disabled by glare from the floodlights. Finally, the needs of colour television cameras must also be considered.
So, when lighting engineers were asked to carry out a preliminary design study for the combined bobsleigh and sledging track at La Plagne in France which will host the 1992 Winter Olympics, it is not surprising that this phase of the project alone took three months to carry out.

CHALLENGING BRIEF

The major problem was to devise a reference plane that would permit a realistic

calculation method. As the angle of the track varies throughout its length, traditional two dimensional plotting methods were inadequate to describe its profile and the design team had to develop a three dimensional approach which utilised height, orientation and inclination. A lighting grid which divided the 1.7Km track into 5m sections was then adopted.

The specification asked for a uniform illumination of some 200 lux along the reference plane, for safety reasons and to allow practice sessions to be followed and recorded on video.

The 305 spotlights were mounted on 40 steel masts varying in height from 7 to 18m. Steel was chosen because of its greater resistance to the salt laden atmosphere and its ability to accept the eccentric loading due to the positioning of some of the spotlights. The exact location of the masts was determined by the need to avoid glare to competitors and to limit the shadows caused by the profile of the track on the surface. The suitability of the ground for the actual installation of the masts was also a major determinant of location.

LIGHT SOURCE CRITICAL

The choice of light sources was equally critical: it is essential to have good colour rendering, a task made more difficult by the surface of the ice. To ensure an uninterrupted power supply, two lighting circuits were used. One comprised halogen lamps (1kW and 1.5kW) and the other metal halide lamps (400W and 1kW) both of which are suitable for a white, snow covered environment. The tungsten halogen fittings are relatively light and their small size minimises wind loading. The lamps used are linear tungsten halogen giving instant lighting and hot restrike. They have an average life of 4000 hours whatever their burning position, and the advantage that their colour temperature remains constant throughout the life of the lamp.

Commissioning of the lighting system on such a different site took three lighting engineers a period of seven days and five nights. First the lights were adjusted for height and direction to a computer designed plan. This first theoretical adjustment of the spotlights was then corrected by visual aim, giving a tolerance of 0.8 lux. Although invisible to the eye, this adjustment was needed to meet the requirements of the specification.

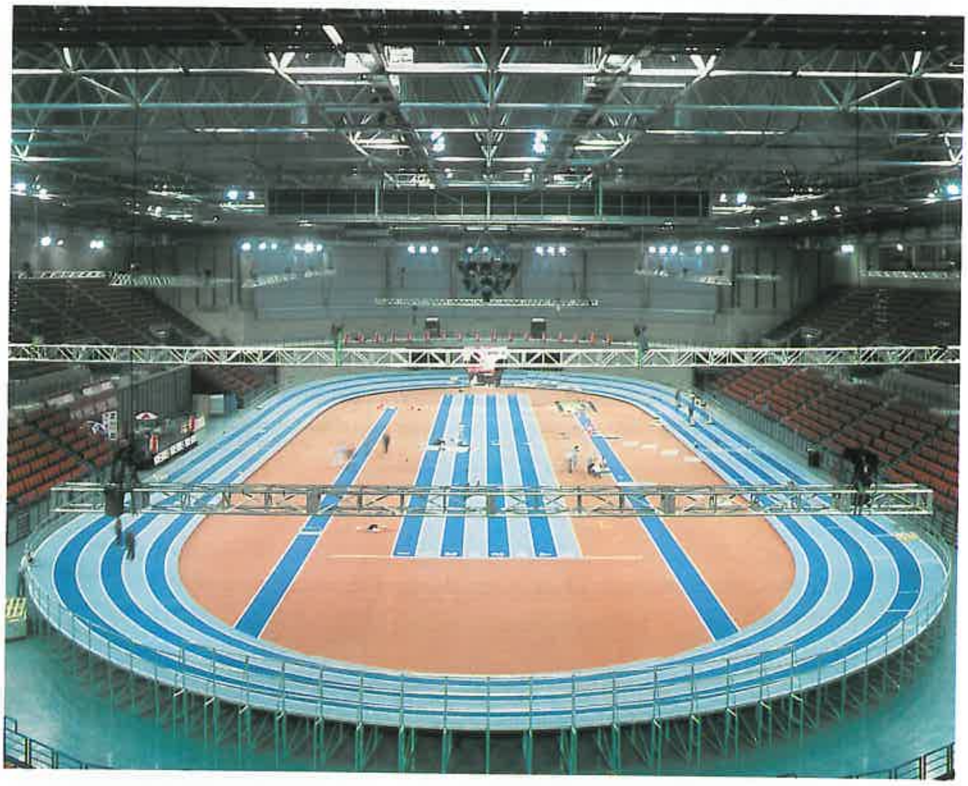
TOP OF THE SPORTS

The National Indoor Arena at Birmingham boasts top class facilities, including the claim to the world's fastest 6-lane indoor running track. The Arena has a maximum capacity of 13000 and can cater for all sporting and entertainment events including the staging of Verdi's opera - Aida.

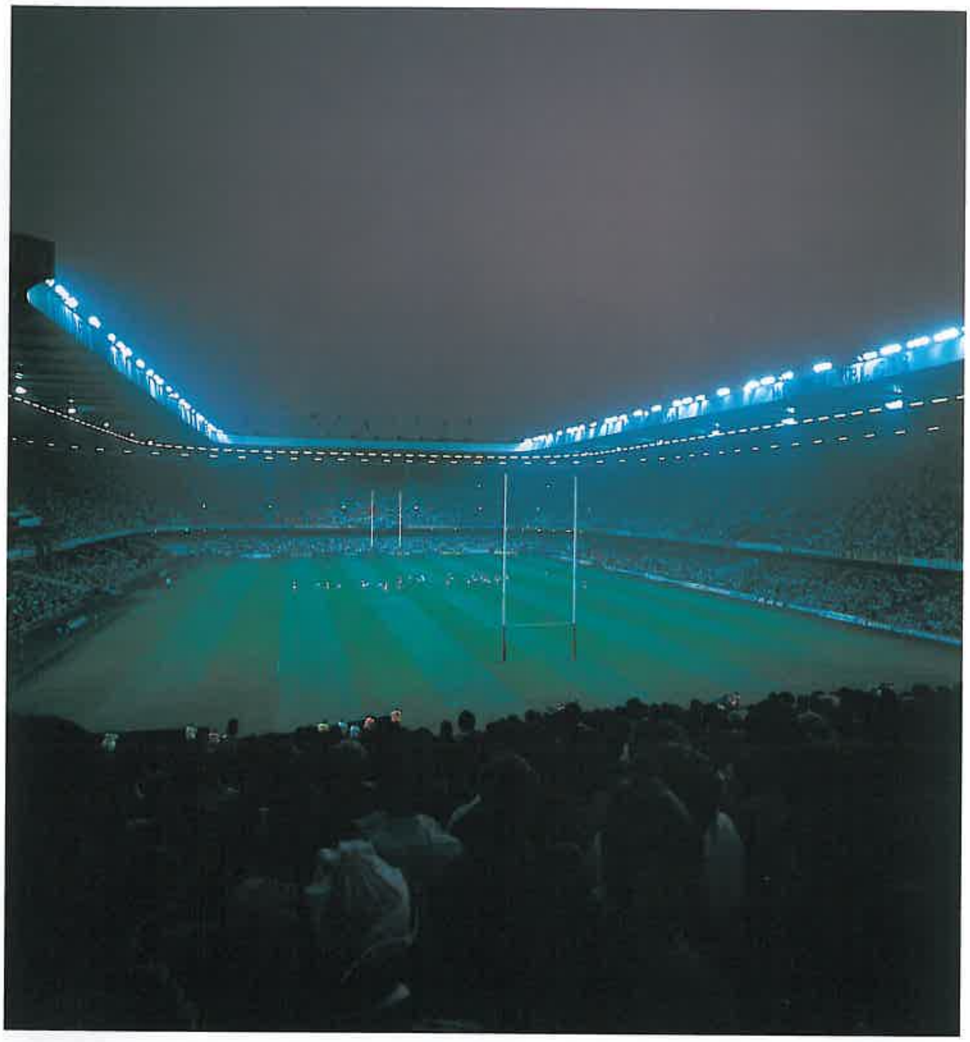
A total of two hundred and fifty four 2kW metal halide floodlights have been installed to light the Arena to world class standards.

The floodlights are controlled by a special computer programme, operated from a central control room or from 4 other positions in the Arena. 184 floods provide the general illumination for full athletics while a further 70 have been aimed and set up to provide localised lighting for specific sports such as ice hockey or table tennis.

The floodlighting is switched at three levels. Full lighting is designed to achieve 1400 lux and enables excellent colour TV coverage.



This can then be switched to 2/3 (900 lux) and 1/3 (500 lux) depending on what type and level of activity is being played. This has the added advantage of optimising energy efficiency. Photograph courtesy of Crown House Engineering.



NIGHT INTO DAY

It was two hundred and ten 2kW metal halide floodlights which turned night into day at the Welsh Rugby Union's National Ground in Cardiff. The lighting achieves over 2000 lux thus enabling excellent colour TV broadcasting.

Pictured above is Singapore's City Hall picked out by 42 high pressure sodium floodlights. The stone clad building - built in 1929 has been restored as part of a scheme to revitalise the Civic District of Singapore. Twenty 70W projectors are positioned in front of the building to give the facade a general, but subdued "wash" of light. The remaining floods, 150W rated, have been placed behind the Corinthian-style pillars creating a sharp contrast between the columns and the back wall thus ensuring that a 3-dimensional view is maintained at night. Finally, a row of warm coloured fluorescent lamps positioned at parapet level completes the effect. The scheme designed with Richard Ong of the Public Works Department restores the buildings elegant and dignified appearance and helps to remind both visitors and residents alike of its important place in Singapore's history.

Shown right is the stunning Castel del Monte de Andria in Bari, Southern Italy-famous for being the only castle in Europe built to an octagonal design and also notorious for its eight dungeons. Flood-lighting is a combination of six 1kW and fourteen 400W high pressure sodium fittings. Average illuminance on the castle walls is approximately 50 lux.

THORN Lighting Limited
International Companies

Australia
THORN ALI Limited
Telephone (2) 604 4300

Austria
THORN Licht GmbH
Telephone (222) 2215110

Belgium
THORN Lighting
Telephone 2 725 7580

Denmark
THORN Belysning As
Telephone (4) 354 0677

Finland
THORN Orno Oy
Telephone (0) 246 901

France
THORN Europhane
Telephone (1) 49 536262

Germany
THORN Licht GmbH
Telephone (2932) 2050

Hong Kong
THORN Lighting (HK) Company
Telephone 578 4303

Ireland
THORN Lighting (Ireland) Limited
Telephone 961 877

Italy
Europhane Illuminazione
Telephone (51) 70 0053

Malaysia
THORN Lighting
Manufacturing Industries SDN BHD
Telephone (03) 550 331 1

Netherlands
THORN Lighting BV
Telephone (2979) 88941

New Zealand
THORN Lighting Limited
Telephone (9) 887 155

Norway
THORN Scanlux AS
Telephone (02) 760350

Portugal
THORN Lighting Portugal
Telephone (1) 847 1142

Singapore
THORN Lighting Singapore
Telephone 747 4539

South Africa
THORN Lighting (Pty) Limited
Telephone (11) 474 0161

Spain
THORN Iluminación Espana
Telephone (1) 556 8469

Sweden
THORN Jarnkonst AB
Telephone (418) 52000

Taiwan
THORN Lighting Taiwan
Telephone (02) 341 9513

Thailand
THORN Lighting Thailand
Telephone (2) 2331714

United Kingdom
& Head Office
THORN Lighting Limited
Telephone 081 905 1313

International Sales
Telephone 0708 766033

UK Regional Sales Offices and Showrooms

Brochure Hotline
081-680 9878

Head Office
Sales and Marketing
Elstree Way
Borehamwood
Herts. WD6 1HZ
Telephone 081 905 1313
Fax 081 905 1278
Telex 915891 THORN G

Midlands
Emmanuel Court
14 to 16 Reddicroft
Sutton Coldfield
Birmingham B73 6AS
Telephone 021 355 8000
Fax 021 355 8492

North East
California Drive, Castleford
West Yorkshire WF10 5QH
Telephone 0977 551212
Fax 0977 514294

North West
Thorn House, The Towers
Wilmslow Road, Didsbury
M20 8SE
Telephone 061 445 9988
Fax 061 445 8191

Northern Ireland
Prince Regent Road
Castlereagh, Belfast
BT5 6QR
Telephone 0232 401122
Fax 0232 401338

Scotland
Thorn House, Industrial Estate
Larkhall, Lanarkshire ML9 2PA
Telephone 0698 886007
Fax 0698 881660

South East
3 King George Close
Eastern Avenue West
Romford, Essex RM7 7PP
Telephone 0708 730888
Telex 897759 THLITE G
Fax Sales 0708 732944
Technical 0708 727370

South West
Thorn House, Penarth Road
Cardiff, Wales CF1 7YP
Telephone 0222 344200
Fax 0222 344240

THORN Lighting Limited is constantly developing and improving its products. All descriptions, illustrations, drawings and specifications in this publication present only general particulars and shall not form part of any contract. The right is reserved to change specifications without prior notification or public announcement. All goods supplied by the company are supplied subject to the Company's General Conditions of Sale, a copy of which is available on request.

THORN