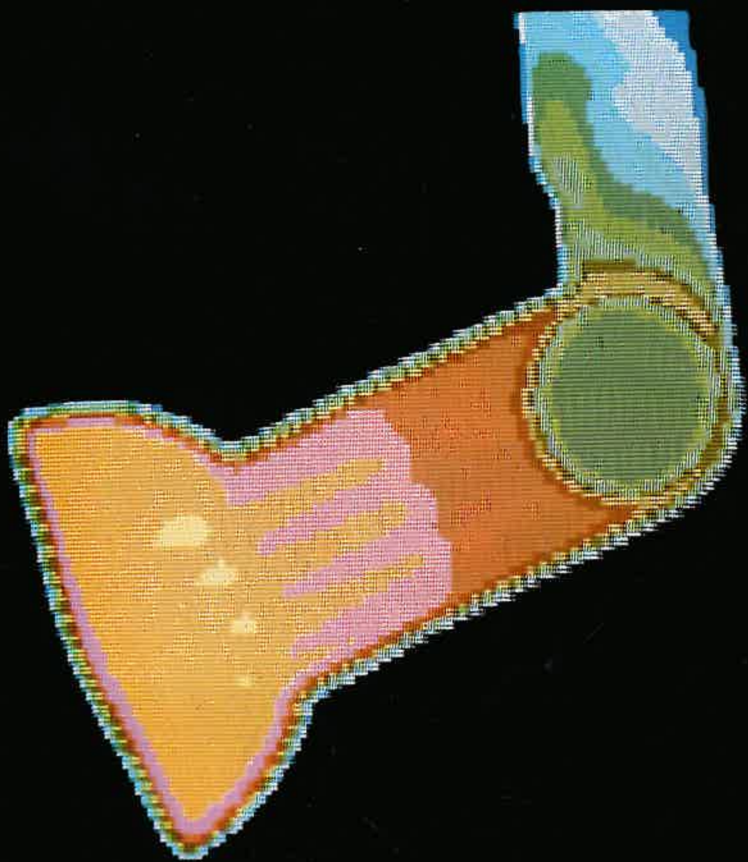
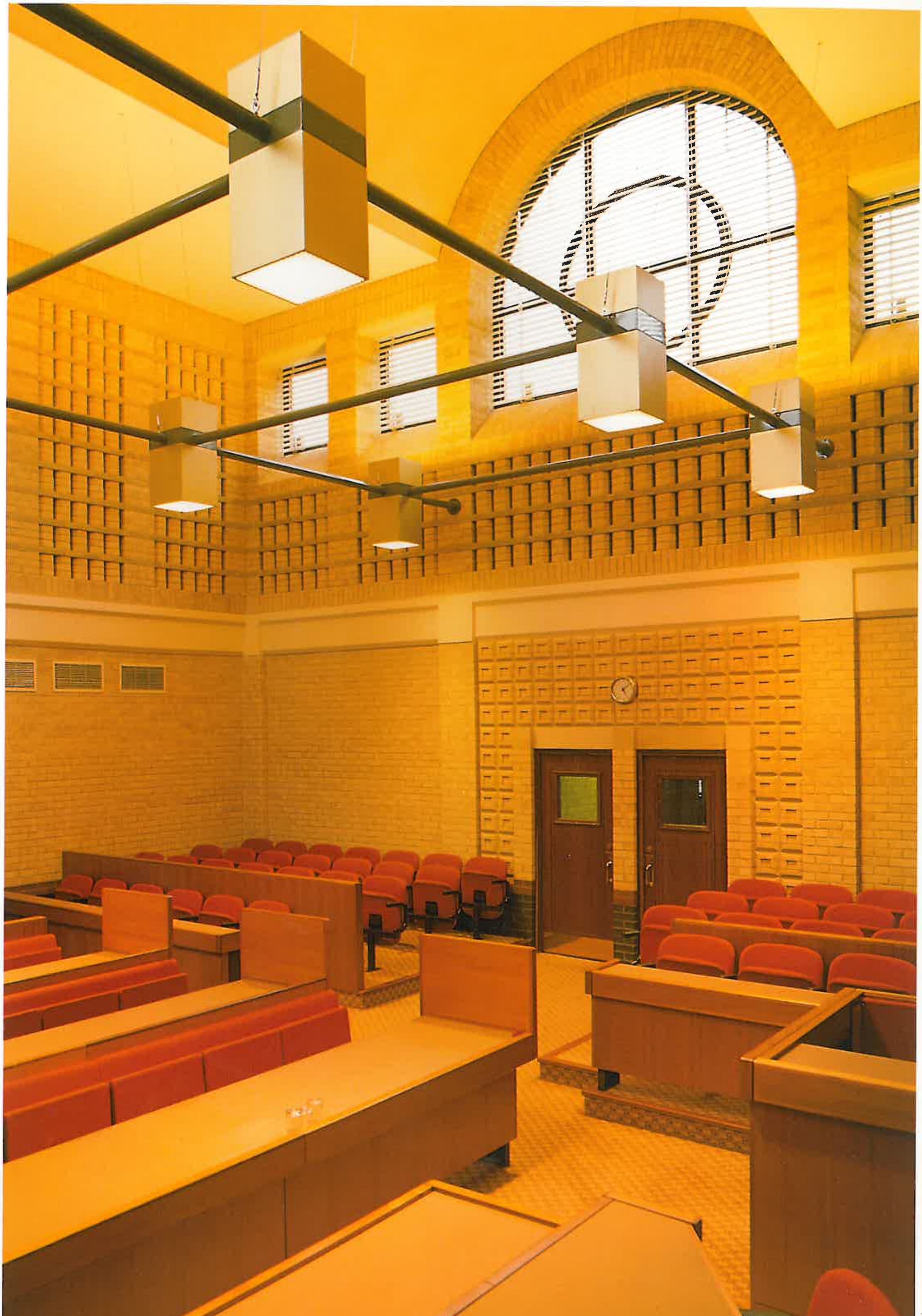
LIGHTING JOURNAL 32





LIGHTING JOURNAL 32

SUMMER, 1991

Front Cover: *Low voltage tungsten halogen display spotlight being subjected to thermal testing. A heat sensitive infra-red camera is linked to video and computer equipment. This generates an image on screen revealing in detail where heat build up is occuring, thus allowing for optimum product design.*
On the inside front cover is a view of the new Crown Courts at Norwich designed by the PSA to compliment the existing adjacent Magistrates Court. Lighting design by Troup Bywaters and Anders is a combination of up and down lighting techniques. Special fittings have been incorporated onto a suspended 'H' frame assembly. Each luminaire houses two deluxe high pressure sodium lamps, a 250W lamp for downward light and a 150W rating for the uplighting effect.
The housings are finished in bronze to compliment the interior design and brown tubular frame. The recessed areas of the courts, including the bench and jury areas are lit with 2D compact fluorescent downlights with low brightness louvres.

Back Cover: *Statoil, Oslo, Norway. Architecturally Statoil's building has drawn high praise and the metal halide flood lighting highlights its features dramatically.*
The inside back cover features the floodlighting of Queen's Tower in Kensington, London. This installation illustrates the typical problems of finding suitable locations for mounting the floodlights and in providing an even illumination for high structures. The 287 foot high tower is effectively floodlit with twelve 1kW metal halide projectors which incorporate a variety of front glass attachments to provide different light distributions and peak intensities. Positioning the floodlights at roof level on surrounding buildings was crucial. The result is a scheme which compliments the Portland stone and models the tower's decorative features — the vertical "ribs", the flying buttresses on the belfry and the domed copper roof.

Offices don't need light. The people who work in them do.
At first glance these two statements appear rather trite but all too often lighting is designed to satisfy the physical requirements of a building rather than the physiological and psychological needs of the office workers. Many installations provide the right quantity of light, it is the quality of the illumination that is unsatisfactory.
In this issue of Lighting Journal we review the CSP Index, a rating system which provides a means by which quality can be measured in lighting installations. Introduced initially for office lighting applications it uses a computer model which analyses the inter relationships between a number of lighting measurements to produce a simple quality index measured on a scale from zero to 100. For the first time it is possible to judge the quality of office lighting in relative terms.
The trend for better quality in the visual environment has been taken up in the UK by the National Lighting Award competition.
Two articles review winning schemes, the floodlighting of the Don Valley Stadium in Sheffield and the lighting of the Cheltenham & Gloucester Building Society head office.
The past decade has seen a number of very considerable advances in lighting practice, management and technology. We print an abridged version of Lou Bedocs' inaugural address as CIBSE Lighting Division chairman which reviews these issues and looks to the future.
From there we go on to review two dramatic floodlighting installations, The Tower of London in the UK and Chateau D'Yquem in France.
The next article in this issue reiterates the importance of basic research and describes a study of exterior pedestrian shopping areas carried out in conjunction with the Bartlett School of Architecture and Planning, University College London. The results are already helping designers of amenity lighting schemes to provide a better and more attractive night time environment.
This is followed by a practical description of the various ways in which we can control the hours of use for lighting. This article shows how substantial savings can be made without compromising quality.

Contents

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North West Electricity Board, opposite, where VDT's are in regular use. The calculated CSP rating (Qi) is 54 showing that over 90% of the office staff are satisfied with their lighting.

***Figure One**: Graph relating CSP Index to opinions on lighting.*

CSP PUTS A MEASURE TO QUALITY

The recently introduced CSP Index is an attempt to achieve what many people would consider impossible — to be able to predict what the worker's opinions about the quality of their lighting will be.

Introduced initially for office lighting installations, it uses a computer model as a basis for balancing the mass of interrelated parameters relating to the lighting equipment, the space in which it is installed, and the people and activities within that space. The result is a simple quality index (Qi) measured on a scale from zero to 100, although, in practice, values much above 70 are uncommon.

COMFORT, SATISFACTION AND PERFORMANCE

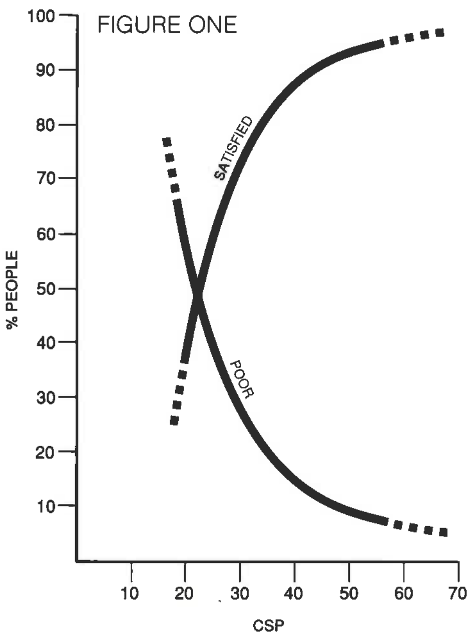
The index is based on the principle that three factors influence perceptions of 'quality' in a lighting installation — visual comfort, visual satisfaction and visual performance. Comfort is concerned with factors such as discomfort glare which disturb people and cause stress, irritation or fatigue. Satisfaction relates to people's feelings about the workplace, whether it appears bright or gloomy, and whether it seems adequately lit. Performance is a more subconscious factor relating to the ability of the staff to do their work well under the lighting conditions.

The CSP Index draws upon existing and new research into the factors that influence people's perception of different lighting conditions, to produce a computer model which is used as the basis for the evaluation process. This takes account of such elements as the horizontal illuminance (Eh), cylindrical illuminance (Ec), glare index (Gl), uniformity (U), distribution factor (DF[F]), colour rendering index (Ra), and the extent of VDU use within the area. This last element is an increasingly important factor in modern commercial lighting.

THE CIBSE CODE

All these factors are covered by the *CIBSE Code for Interior Lighting* which gives a wealth of information on how to design a quality lighting installation and CSP does not replace the Code. But many installations fall well short of the requirements of the Code. Although many designs never 'see' a code of practice, the few that do are limited to just the lighting level recommendations.

A lighting installation designed to the *minimum* requirements of the Code would produce a CSP index of about 35. This would correspond to 80 per cent satisfaction with the office lighting as CSP measures quality in terms of the probability that people will be satisfied. This may, at first, appear reasonable until it is remembered that if 20 per cent of staff are dissatisfied with their working environment it could have a major influence on performance, staff morale and absenteeism. Figure 1 enables these probabilities to be assessed. For a given CSP Index the percentage of people holding a certain opinion about the office lighting can be read off the graph. For example a CSP Index of 40 would produce 85 per cent satisfaction while 70 would produce 95 per cent satisfaction. In practice lighting is not the only cause of dissatisfaction and therefore a CSP Index of over 70 is unusual.



THE NEED FOR A QUALITY INDEX

Lighting represents 15-16 per cent of total electricity use in developed countries; about 9 per cent of the total commercial. Not only is the commercial sector the largest user of lighting energy but lighting constitutes some 50 per cent of electricity consumption in the average office. This is a strong incentive to invest in energy-efficient lighting.

It is important, however, to view these costs in the context of total operating costs: The capital and operating costs of lighting a modern office represent less than 0.5p in the pound whilst wages and associated costs consume 84 pence in the pound.

Thus a 30 per cent reduction in lighting load — which is readily achievable by a switch to modern technology — would represent a saving of less than 0.15p in the pound. In contrast, a 1 per cent improvement in performance by the workforce would be worth nearly six times this figure. Expressed another way, the money saved by a 30 per cent cut in lighting costs is equivalent to 40 seconds extra work time in the average day or one headache per worker per year! So we shouldn't aim to save energy, but to save energy whilst improving productivity.

Studies over the years have shown that real and perceived improvements in the working environment can have a dramatic effect on the performance of the workforce. As far back as the 1920's, the experiments of Mayo in the Hawthorne works in Chicago, showed that productivity had more to do with worker satisfaction than with illuminance — the 'Hawthorne effect'.

In a more recent example an industrial company improved its lighting with a scheme that, it calculated, would achieve a two-year payback in terms of energy saving. At the same time because of better lighting, a 5 per cent improvement in productivity was hoped for; this they calculated would yield a payback in just five days! In practice productivity improved by 8-10 per cent!

CSP DEVELOPMENT PROGRAMME

It was against this background that, in December 1988, a programme to develop a quality index for office lighting installations was initiated. "The object was not to develop a new design method but to use existing criteria and establish their interrelationship with worker's judgements" says Bob Bell, THORN's chief lighting engineer. He des-

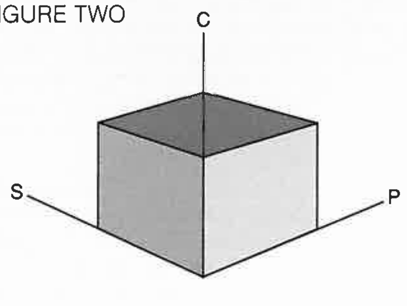
***Figure Two**: CSP Visual Quality Solid.*

cribes the Index as a barometer by which it will be possible to judge the overall effectiveness of the design as perceived by the workforce.
An independent lighting consultant, Dr Bob Bean, was commissioned to pioneer the work. In the first place existing worldwide research into human response to different lighting conditions was examined. The object of this was to bring together all the significant findings and see if they could be combined to produce a single meaningful index.
At the heart of this process is the theory that we respond to three interrelated criteria — visual comfort, visual satisfaction and visual performance — and that if they could be represented by a single index in the range 0-10, then the quality index could be represented by the formula:-

$$Qi = \frac{3 \times C \times S \times P}{C + S + P}$$

This formula ensures that all three elements must be given due attention. It can be imagined as a box with sides of lengths C, S and P. The CSP Index is similar to the volume of the solid and the highest CSP results when the volume is biggest (fig 2). In human terms, it means that people's judgements about their visual environment will be most influenced by the factor that is poorest, and increasing the other two factors will not do much to compensate for the problem.
As a result of the first phase, Dr Bean produced a complex family of interrelated formulae which were brought together in a computer model to yield a quality index of this form.

FIGURE TWO



PHASE TWO

The next step (Phase Two) was to test his hypothesis experimentally. The decision was taken to use real people in real office environments rather than laboratory conditions. The reason for this was simple. If it was to be of any practical use it had to work in the real world not the laboratory and lighting research is littered with results that never worked when applied to the real world.
Phase Two of the programme was thus a pilot study by THORN's own research staff in various company offices looking at the attitudes of office staff during their normal work in a range of office environments.
The results at this stage were better than had been expected and provided some additional data to enable the system to be refined. Among the patterns that began to emerge was the importance of cylindrical illuminance and the relatively lower significance of such things as colour temperature. The question of daylighting was taken into consideration and it appeared that whilst the *presence* of windows provides an important link with the outside world, satisfaction does not vary dramatically with distance of the subject from windows.

PHASE THREE

Phase Three was to look for independent verification. Five academic institutions were commissioned to carry out tests in a variety of office buildings across the country to enable human response to different conditions to be compared with the results predicted for the same installations using the proposed CSP Index.
The teams used a simple test to determine worker's responses to their office environment. They noted the types of luminaire employed so that manufacturers' photometric data could be consulted and were also given a kit to enable them to measure illuminance, cylindrical illuminance, colours and reflectances and room dimensions. They also had a camera so that they could photograph the installation.
The test was restricted to offices with overhead lighting; offices with uplighting or localised lighting were excluded. Some of the offices had VDT's while others did not. The researchers were not told anything about CSP, so that they could not introduce accidental bias and their measurements would be of a similar quality to what might be expected in practice. Their results were scanned at the end for test errors, and for omissions and to ensure consistent experimental method.
Combined with the pilot study, this meant valid data had been obtained for over 44 offices with a total of 650 occupants — a much larger sample than is normal for such exercises.
It is interesting to note that 25 per cent of the offices surveyed failed to meet the basic illuminance recommendations of the CIBSE Code; 30 per cent had excessive discomfort glare and 9 per cent had too much light on VDT screens.

A SUCCESSFUL OUTCOME

The results of the survey were very positive in confirming the effectiveness of the CSP model as a means of discussing workers opinions about the quality of their lighting. Many statistical analyses of the results were conducted and produced similar results! They indicated that the correlation between illuminance and subjective assessment of the quality of lighting is not as close as the CIBSE Code suggests while the correlation between the CSP Index and subjective assessment is significantly better.
An important test is the statistician Rank Correlation which tests how good a system is at putting things in the same order as the assessments. The CSP Index yielded a rank correlation coefficient of 0.54 compared with 0.33 for horizontal illuminance. Furthermore, the analysis indicated a significance of 0.03 per cent, ie the probability of such close correlation by chance is less than 3 in 10,000.
The CSP Index model allows for subsequent refinement. It already takes account of modern VDT use exceedingly well by including the proportion of VDT users and the time for which the screens are used but Professor Wilkin's work on the effect of high frequency lighting on opinions was still in progress while the system was being developed. This will, however, be taken into the system in due course.

FACTORS HIGHLIGHTED

The results of the CSP development work and evaluation indicated a number of factors:

* A meaningful quality index (Qi) embracing visual comfort, satisfaction and performance is possible and the results correlate well with practical tests.
* Cylindrical illuminance (Ec) is a significant element in quality.
* Other significant criteria are horizontal illuminance (En), distribution factor (DF[F]), glare index and VDT use. These and the cylindrical illuminance all need to be correctly measured or calculated.
* No special, new measurements need to be recorded other than cylindrical illuminance, which, although not new is unfamiliar to many.
* Uniformity (U) is not as significant as had once been thought.
* Correlated colour temperature (CCT) is almost negligible in its effect upon the CSP calculations. However, it may emerge as a more significant element in localised lighting or industrial lighting and is included in the model for these future purposes.

USING CSP

The CSP Index calculations are incorporated into a computer model which is offered as a Shareware program for use on personal computers. It is available for use by anybody who wishes to use it, subject to normal Shareware software conditions. (ie the copyright is retained by the authors). It can be used at the design stage to generate a CSP Index for a proposed lighting scheme or it can take actual measurements from an existing installation.
When used at the design stage, the intention is that the lighting engineer should design the scheme first using the appropriate codes of practice and then use the CSP program to obtain an Index for the installation to determine the probable human opinion of the lighting quality. If he then wants to improve the installation quality, he can change selected parameters on the screen to evaluate the options available.
When the CSP program is run, the user is presented with a single screen display into which he inserts information in five groups:

* Data about the room (Length, height, height of luminaires above the work plane, effective ceiling, wall and floor reflectance and glazed/wall area).

* Data about the luminaire (Distribution factor, downward light output ratio, upward light output ratio, light modulation ratio at IOOHz and whether high-frequency gear is used).
* Data about the light source (Colour rendering index and correlated colour temperature).
* Data about the room illumination (Average horizontal illuminance, average cylindrical illuminance, average uniformity on desks and discomfort glare index).
* Data about the office workers (Number of workers, number who use VDTs, per cent of time they use VDTs and whether the work is especially demanding?)

All this data remains visible on the screen while the software calculates the CSP Index which is then displayed on the screen below the input data.

In an installation where, say, 20 per cent of staff used VDTs it would be possible to input the same data separately for the VDT users and the non VDT users to get a separate quality index for each group and so determine how well it met the needs of each group, as well as a composite index for the whole staff.

The CSP software includes a full text file of notes on the CSP Index with guidance on how to measure, calculate or otherwise obtain the input data. It also provides material to enable a separate user survey to be carried out (following the same criteria as the surveys used in the development programme) to enable the results of the CSP evaluation to be verified.

Bundled together in the same software package in the Hyperlight program, which Bob Bell describes as "an interactive aid to the CIBSE Code". Written by J Lynes and W Burt, this is a text-orientated program containing explanations and guidance on office lighting which can be called up on screen.

CONCLUSION

Bob Bell admits that at the outset of the project he had not thought it possible to produce a robust and viable index. Research work of this type with real situations seldom produces a clear result. "The biggest surprise for us was that it worked" he admits. The result of Dr Bean's work has exceeded expectations, producing a remarkable degree of consistency. "It's not perfect" admits Bob Bell "but it is a powerful tool by which it is possible to judge the quality of office lighting in relative terms, and it is the best measure yet of what the workers will think".

"It is like using a barometer to judge the weather" he says, "It is simple to use and gets the right answer most of the time. When the index increases so does office lighting quality and when it decreases so does office lighting quality. That's a major step in understanding what makes office workers happier and offices run better. For the very first time we have a lighting measure which looks at lighting from the office worker's point of view that will benefit the employer and employee alike".

At present the CSP Index is restricted to offices with conventional overhead lighting. The concept could be extended in future to include offices with localised lighting or uplighting. If it becomes accepted it will be extended to apply to factory, warehouse and other forms of lighting. But first the CSP Index for office lighting quality needs to gain widespread acceptance.

So far the indications are all positive.

Bob Bell and Dr. Robert Bean — the main players in the CSP Index research project.

***Left**: The dramatic central atrium at the Cheltenham and Gloucester Building Society.*
***Below**: A general view of the interior clearly showing the modular recessed fittings.*

THE 1990 NATIONAL LIGHTING AWARDS

The fourth National Lighting Awards were presented by the Lighting Industry Federation (LIF) on 15th November 1990. These awards underline the role that quality lighting plays in everyday life by rewarding excellence and innovation in well designed lighting schemes. The LIF provides a secretarial function in the assessment of entries with the final decision resting entirely with a panel of independent judges.
THORN installations were winners in two categories, one in the Commercial Section and the other in the Leisure Section. The Civic Section was awarded to The Imperial War Museum and no award was made in the Industrial category.

COMMERCIAL SECTION WINNER

Cheltenham and Gloucester Building Society, Barnwood, Gloucester

The new headquarters for the Cheltenham and Gloucester Building Society is situated close to the M5 motorway at Barnwood on the outskirts of Gloucester. An imposing granite clad building it is set in landscaped surroundings with its own three storey car park providing space for 460 vehicles and also provides staff recreational facilities.
The main building has a gross floor area of 22,000 square metres on four floors of 'hi-tech' electronic offices with dedicated computer suites and ancillary areas. The offices are generally formed around the dramatic central atrium which serves as the main access to the floors via elevators and staircases and allows a deep plan concept to be adopted. A further eight perimeter staircases give additional access to the floors, and provide means of escape in the event of fire.

THE LIGHTING DESIGN BRIEF

Two factors mainly set the parameters for the lighting design brief: the special ceiling and the high level of VDT use.
The profiled ceilings in the general office areas are of perforated metal construction and create an interesting feature within the 7.2 metre module formed by the structural columns. This strong ceiling design was the principle influence on the final luminaire design and layout adopted. A square layout was preferred to complement the ceiling design and the architect considered that a square luminaire would also be the most appropriate.
Apart from providing the necessary 500 lux, an important factor was to allow complete flexibility with the orientation of VDT screens and workstations without users experiencing any glare, so that the optical performance of the luminaire was to be within the criteria set out in the CIBSE Technical memorandum No 6. *
Complete flexibility of use of the office space was essential so that there was a requirement to be able to sub divide the 7.2 metre module into 16 in terms of ceiling, electrical and mechanical services. This meant that the luminaires would be required on 1.8 metre square centres.
Integrated emergency lighting had to be provided.
Finally, in the atrium, a decorative and spectacular lighting design had to be provided in order to highlight the strong architectural features.

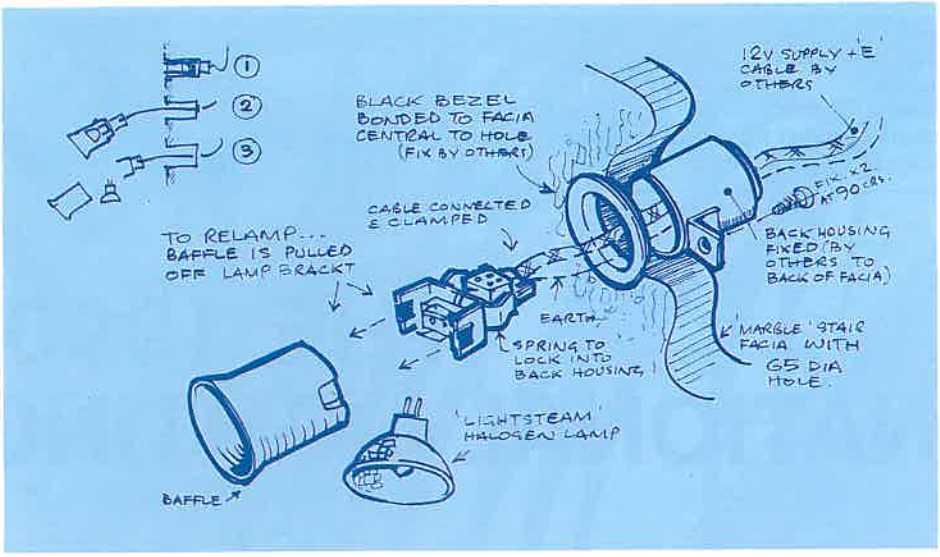
MEETING THE BRIEF

In order to achieve the minimum requirements of 500 lux average on the work plane the most appropriate combination in this particular case was judged to be twin 24 Watt 2L compact fluorescent luminaires with 16 cell VDT louvres designed for CIBSE compliance. It was also required to allow return air from the office space to be extracted via the luminaires. This would serve several functions. The ceiling pattern could remain intact without the intrusion of extract air grilles; it could also ensure optimum performance of the temperature-sensitive compact fluorescent lamps and keep the VDT louvres, reflecting surfaces and lamps clean and free from dust.

"MOCK UPS" PRODUCED

As a result of these initial proposals, four prototype luminaires were produced for use in a 'mock up' of the ceiling system. Prior to these tests photometric and air handling tests were carried out at the Jules Thorn Lighting Laboratories in Enfield, North London. It was then possible to produce more accurate illuminance predictions including prediction illuminance plots. Optimum lamp performance was found to occur when extracting 8 litres per second via each luminaire. As a result, the size of the apertures in the body and the width of the slot in the perimeter trim could now be accurately determined.
It was also decided to incorporate air flow sensing devices within the by-pass slots on the perimeter trims for control of the VAV air conditioning system.
Samples of the 16 cell louvre optic were produced from four different grades of aluminium varying from full specular to semi-specular finish. All would allow compliance with relevant CIBSE guidelines and would offer low iridescence when used in conjunction with 2L multi-phosphor lamps. The final choice on appearance was made and a semi-specular material was selected.
As a result of producing the prototypes some minor design changes were made to the trims and side suspension arms to ensure the best possible integration, both aesthetically and mechanically.

This engineering sketch shows the recessed low voltage stairway lighting. ***Below*** *can be seen the final installation.*



THE ATRIUM

The Atrium exists to provide a dramatic first impression to the visitor and a lighting solution to do justice to this first impression had to be produced.

Natural light in the atrium is admitted via a glass roof above an open cell louvres structure which incorporates an access walkway for service and maintenance. This structure is designed to admit maximum daylight which is supplemented by special metal halide down lighters incorporated into the cells. The luminaires contain powerful 150W lamps which produce a subtle effect on the splendid floor below and wash the walls with clean, crisp white light.

Indirect lighting is also provided from 250W metal halide floodlights, concealed along each side of the roof (above the top floor level) to provide a contribution to the general illumination as well as to highlight the curves of the roof structure.

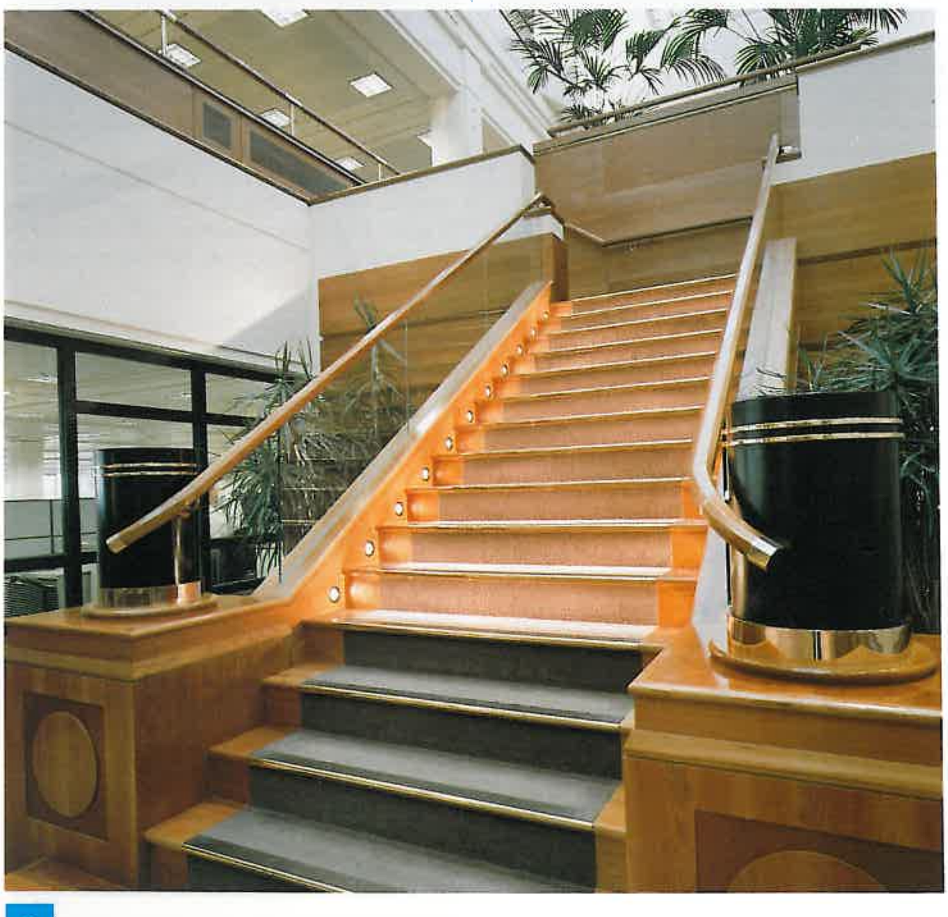
LIGHTING THE STAIRS

For added sparkle 50W low voltage tungsten halogen lamps are recessed into the sides of the splendid granite and timber clad stairs in specially designed and inconspicuous luminaires. These are fed from remote transformers and controlled by compatible 'back to back' thyristor dimmers preset to produce the desired illuminance on the stair treads as well as to extend lamp life.

The correlated colour temperature of both the metal halide and tungsten halogen lamps (undimmed) is 3000K and this complements the lighting in the offices.

LIGHTING CONTROL

The lighting system is controlled by a programmable logic control system, providing user flexibility for control, switching and automatic energy management routines over a normal working day. Automatic switching takes place to account for the varying occupational requirements. Local manual override facilities are provided to enable individual user's requirements to be met for periods outside the programmed working day. The general offices have an installed lighting load of 82.7kW and the sound energy management principles are complemented by group lamp changing and regular cleaning schedules — all of which fall under the remit of an appointed energy manager.



ATTENTION TO DETAIL

Great attention was paid to detail such as the quality of mitres on the trims and the louvre flanges. The narrow trim was finished to match the colours of the ceiling panels and the inside of the slot finished black to create a crisp, defined perimeter detail.

The final decision was yet to be made on the colour temperature of the 2L lamps. Tests were carried out in a colour comparitor with samples of the principal materials and colours proposed in the offices and atrium areas. The warmer appearance of the 3000K lamp was eventually chosen. This lamp has excellent colour rendering properties (Ra 85).

A proportion of the luminaires were provided with emergency lighting ballasts to provide three hour operation on mains failure from a central battery system throughout the office space. The final design produced a scheme which gave the office occupants over 600 lux and an extremely comfortable, glare free lighting system.

OTHER LIGHTING FITTINGS

The ancillary areas are too many to describe in detáil. However it is worth mentioning that the eight perimeter stair-cases are illuminated by a vertical tubular architectural system incorporating emergency lighting and the car park uses specially designed 125W super deluxe mercury luminaires mounted in the structural coffers.

THE VISUAL EFFECT

The overall impression is of great spaciousness and a feeling that this is a very comfortable place to work. The quality of the finishes and the great attention to detail reflects the high priority given to staff comfort.

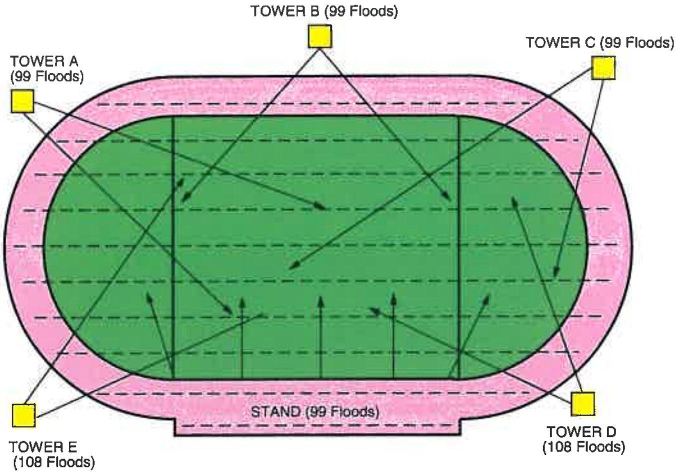
* CIBSE Technical Memorandum TM6 has been superceeded by LG3.

Client: Cheltenham & Gloucester Building Society

Electrical contractor: N. G. Bailey & Co.

Lighting design: Roger Williams, Hoare, Lee & Partners Bristol and Tom Fairhurst, THORN Lighting.

At the top of the page can be seen details of the floodlighting mounting positions. At the bottom of the page is the spectral distribution of the 2kW metal halide light source.



LEISURE SECTION WINNER

Don Valley Stadium Sheffield

The Don Valley Stadium in Sheffield is a spectacular structure by any standards with its striking architectural cantilever roof. It has been designed and commissioned by the Design and Building Services Department of Sheffield City Council in order to host the World Student Games, later this year.

Sheffield secured this international prize against stiff opposition from other major cities.

Apart from being one of the major construction projects in the North-East of England, the 25,000 capacity, all seater stadium is a flagship designed to attract world class sporting stars.

THE CHALLENGING BRIEF

The Don Valley lighting brief was challenging. Firstly for such an event as a world games, high level, quality lighting was needed for the sporting arena to facilitate excellent TV coverage. Such levels had to comply with all the major international sports codes of practice, including the requirements of the International Athletics Association, CIE Publication Numbers, 28, 67, and 83 and the CIBSE sports lighting guide. Recommendations were also taken from UEFA and BBC Television.

The brief also required the lighting to suit many different activities whilst keeping operating costs to a minimum. While the stadium has primarily been designed for athletics it is to be used for many other sporting activities such as rugby, football and even floodlit cricket. To cater for such a mix of needs including the demand for training activities, multiple switching levels were a necessity.

In addition to the lighting of the arena a system for floodlighting the stand roof which provides a striking architectural feature for the whole complex was an important part of the lighting design brief.

Following the findings of the Taylor Report, a vital consideration was safety, with emergency lighting needed for all spectator and stairway areas.

The ease of maintenance and electrical installation were other factors considered from inception of the project.

ILLUMINANCE LEVELS

As with any major sporting stadia where television coverage is provided the lighting requirements relating to the camera take priority. The lighting criteria for colour television is often expressed in terms of illuminance on a plane normal to the camera position. However, due to the large number of possible camera positions and the need to cover a range of different sporting activities this was impractical at Don Valley. The specification was therefore based on four planes inclined at 15° to the vertical as described in CIE 67.

The average illuminance over these planes was to be 1500 lux. Initial computer calculations indicated that this would produce approximately 2000 lux over the horizontal plane. This value was then used as a basis for the required switching levels chosen as 2000 (full on), 1000, 500 and 250 lux. In addition each of the five floodlighting masts and the roof mounted floodlights could be switched individually.

To achieve uniformity of illuminance an overall figure of 0.6 (E Min E Average) was used for both horizontal and inclined plane grids.

CIE 83 recommends for stadiums a high efficiency light source with a colour rendering index (Ra) of 65 or more with a colour temperature between 4000K and 6000K. The floodlight must give high system efficiency with excellent glare control and preferably be small to minimise lighting mast costs.

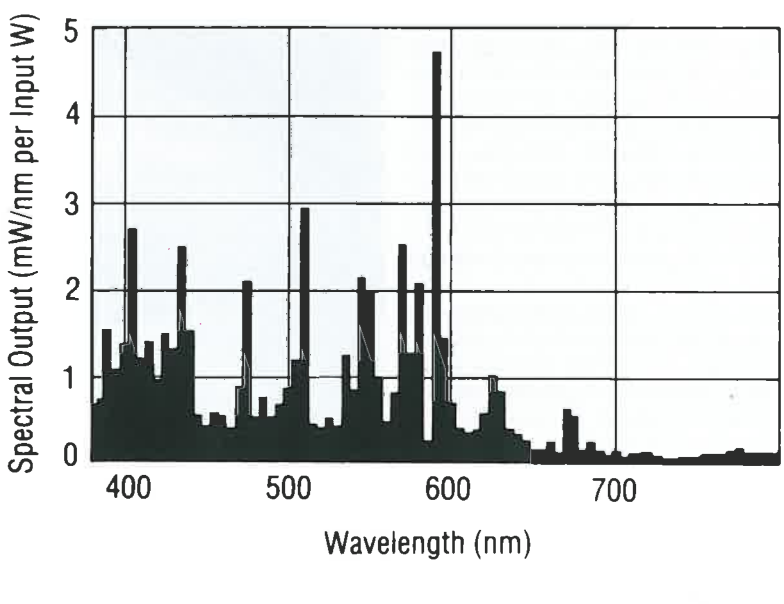
To meet these design criteria and minimise the effects of spill light and glare many computer simulations were carried out for Don Valley. The final solution was 612 2kW metal halide floodlights mounted on 5 masts and along the stand roof. (see above) To comply with the requirements of CIE 28 for a 30° angle from pitch centre to the floodlights it was decided to use 42m masts on a raised embankment giving a total height above pitch level of 60m. To cover the area immediately in front of the stand it was found necessary to mount floodlights on the leading edge of the stand at an 18m mounting height; these were aimed at lower angles.

It was a fundamental requirement that all floodlights must have a sharp "run-back" to minimise glare.

LAMP DESIGN

The 2kW linear metal halide lamp and Metaline floodlight combination was selected for a number of reasons. Unlike traditional discharge floodlighting lamps where the arc tube is mounted in an outer, glass jacket (or bulb), the MBIL lamp consists of a high pressure mercury vapour discharge with metal halide additives, operating in a bare, cylindrical arc tube made of quartz. The arc tube with lamp caps at each end is fitted directly into a suitably designed luminaire which acts — in effect as the outer jacket. The lamp has a high lumen output (200,000 lumens), long life (in excess of 6,000 hours) and good lumen maintenance characteristics. Being a metal halide lamp it also provides good colour rendering (Ra 65) at a colour temperature of 5200K — that blends with natural daylight and is ideal for use with colour TV cameras.

SPECTRAL DISTRIBUTION

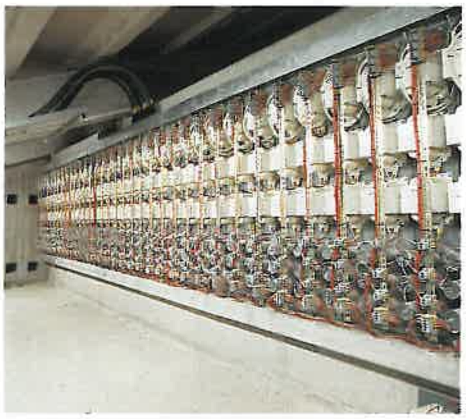


FITTING TECHNOLOGY

The key features of the MBIL lamp design give great advantages in terms of the lamp and luminaire package. The reduced physical dimensions of the lamp — typically 5% of the volume of a jacketed tubular lamp — mean that the luminaire can also be compact, minimising size and weight. Being slim and double ended the MBIL lamp can also be accurately positioned within the luminaire ensuring precise light control from the reflector system. A selection of reflectors allows the choice of three different intensity distributions to be made for the one floodlight. For the Don Valley scheme a specular narrow beam reflector giving a symmetrical distribution in the vertical plane was used for long throw work and an asymmetric version used to cover the "fill-in" areas. Both types of floodlight were fitted with a baffle in front and above the lamps. This serves primarily as a glare control device which increases the rate of intensity run-back above the peak reducing spill light at high angles. The baffle also redirects some of the lamps flux it intercepts into the beam below the peak intensity, which for the asymmetric system improves the utilance for the scheme.

ELECTRICAL SUPPLY

Electrical control for all masts, stands, decorative lighting and safety/emergency system was by a microprocessor control system. The electrical layout had to allow for both group and individual switching to the masts and the stand.



The six main lighting groups (the 5 masts plus the stand roof) each have their own ventilated control rooms. As the ignitor for the lamp is integral with the floodlight this simplifies installation as attenuation of the ignitor pulse due to cable capacitance can be ignored. As the effect of voltage drop in terms of reduced lamp power and resultant light output is important at Don Valley, some cable runs were up to 200m long. Great care with cable sizing was also taken to ensure that voltage drops to the lamp were at a minimum. In this respect, one advantage of the 2kW MBIL lamp is that it operates with high arc volts and low lamp current. Low lamp current is of considerable benefit in keeping cabling from lamp to control gear to a minimum size. This was especially relevant as multi-core cables were employed.

The 2kW MBIL lamp is designed to operate between phases at 380/400/415V. For a balanced load the lamps were grouped in threes using a triple control gear set supplied via triple pole circuit breakers. To maintain a balanced load the breakers were arranged to "trip-out" all three circuits should a fault occur in any one circuit. As power factor correction was supplied to individual lamp ways any problems with bulk correction were overcome.

Supplementary to this added protection was offered by a phase balance relay that would cut power to a particular control room in the event of a phase failure.

On the facing page is a general view of the stadium, while below, is one of the main lighting control rooms. ***Figure One*** *illustrates the run up characteristics for the 2kW lamp and* ***Figure Two*** *the MBIL 2kW circuit. At the foot of the page is the indirect lighting of the stand.*

FIGURE ONE

RUN-UP CHARACTERISTICS

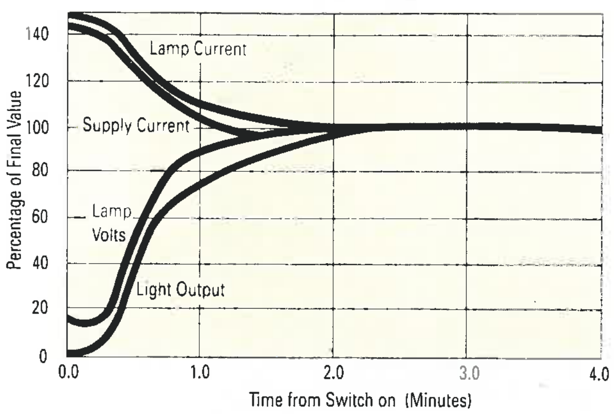
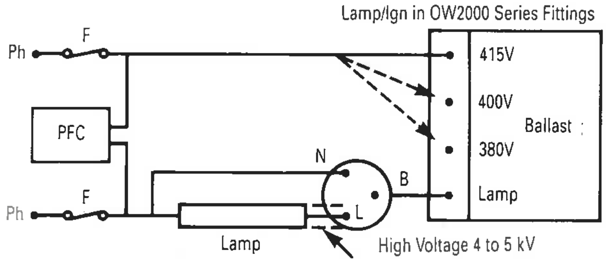


FIGURE TWO

2000W MBIL CIRCUIT



To keep the maximum demand charge to a minimum an automatic time delay of 1½ minutes was allowed for each group of floodlights on masts or stand roof at each switching level. This delay will allow the circuit current to return to the normal steady state condition (see run up characteristics). Full "power-up" for the whole system takes 23 minutes.

INSTALLATION

The mast mounted floodlights were installed in banks on the headframe, each bank corresponding to a different switching level. The headframe was designed to allow full movement of the floodlights in both horizontal and vertical planes. To this end the frame was canted forward at 15° to avoid the mutual obstruction of floodlights in the vertical plane. As the structures were likely to be in the flight path of a new airport nearby each had obstruction lights with dusk to dawn photocells attached.

The floodlights on the stand roof were mounted on specially designed triangular lighting trusses positioned just underneath the leading edge of the roof.

HIGHLIGHTING THE STANDS

It was decided at an early stage that it was important to contrast the lighting of the spectator areas with that of the main areas. The warm colour of high pressure sodium was selected and fitted in floodlights to uplight the white curved canopy of the stand. These are located on the trusses and at the rear of the stand. With this system the roof becomes a luminous feature of the complete stadium and at the same time gives the required 100 lux minimum illuminance level over the stand seating areas.

In total eighty four 400W SON-TD luminaires were installed, the necessary control gear mounted either on the trusses or at the rear of the stand.

SAFETY

Safety and access lighting for the stand areas is provided by 110V 500W tungsten halogen floodlights mounted to the lighting trusses and powered by remote batteries. The resulting lighting level is 5 lux.

Finally six supplementary 2kW floodlights were used to cover the stair access ways and a car park area opposite the main stand. These were mounted on columns A,B and C. (See Page 9)

OLYMPIC FLAME

Lighting to this area to the east of the stadium has been provided by very narrow beam CSI compact metal halide floodlights mounted on masts C and D and producing a vertical illuminance of 400 lux. Construction of the actual "flame" has yet to be completed.

COMMISSIONING

Commissioning has been carried out to ensure that the specified lighting levels, uniformity and glare have been realised.

The first lighting survey indicated that the designed illuminance criteria were achieved. The maximum glare rating of 41 is well below the 50 limit set by CIE technical committee 5-04 draft report.

The canted headframe arrangement proved successful in both offering great flexibility in aiming and in minimising the mutual obstruction of floodlights.

Strong shadows were eliminated by the complex aiming technique whereby floodlights from different mounting positions were aimed at the same specific point. It was also apparent from illuminance measurements that the illumination to the spectator areas was sufficient so that acceptable contrast ratios for camera work were produced.

CONCLUDING THOUGHTS

The major achievement of this project is the harmonization of the illuminance requirements for major sporting activities, together with a lighting effect which compliments and enhances the structure of the stadium by night. The stadium is the first to take full regard to safety standards laid down by the Taylor report. Great flexibility has been achieved by the switching permutations enabling economy control and quality to be achieved.

The first major sports event, the McVitie Games, was held at Don Valley in September and was reward with the highest attendance with a UK athletics meeting for over 25 years. A success that the stadium is sure to build on. But perhaps the finest accolade so far for Don Valley was winning the 1990 National Lighting Awards (Leisure Section) for innovative and creative lighting design.

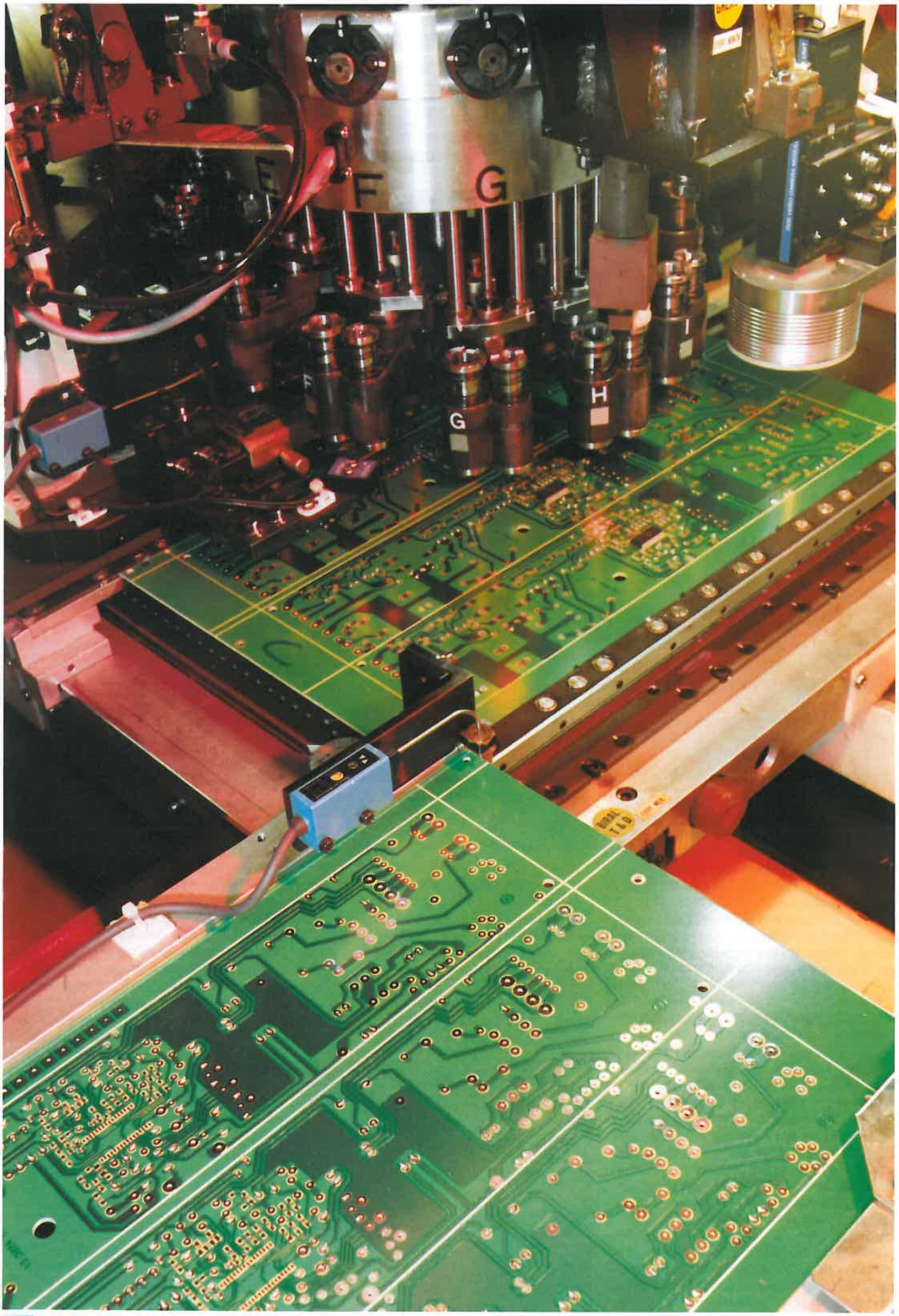
Client: Sheffield City Council

Consulting Engineer: Department of Design and Building Service, Sheffield City Council.

Lighting Design: John Hugill, Tony Andreou, THORN Lighting. Peter Ibbotson, Sheffield City Council.

Architect: N. T. Wood, Sheffield City Council.

Electrical Contractor: William Steward, Leeds



Left: *Electronic components being placed on to the printed circuit board of a controllable high frequency electronic ballast.*
Table One: *Electricity use in lighting in the UK.*
Table Two: *Luminous efficacy of main lamp types.*

LIGHTING IN THE ELECTRONIC AGE

Lou Bedocs is Technical Director, UK of THORN Lighting. He recently gave an address as CIBSE Lighting Division Chairman. The following is an abridged version.

The 1980's have been dubbed "the electronic age" and as we journey the 1990's it is fitting to review the situation and read the signs of the future.

Lighting and electronics have ruled most of my working life and I would like to examine the role of lighting in the electronic age.

LIGHTING PRACTICE

Electronics has had a major impact on our lighting products, schemes and design techniques. But motivation for change was also foisted upon us by the energy crisis. This spurred on much activity with the user and in the industry. It is a relief to note that the initial pressure on energy conservation by the "Save it" campaign with the resultant risks of people working in poor lighting conditions has evolved into a more positive philosophy on energy management with the "use it effectively" message.

The squeeze on light levels has been successfully withstood. For us this was relatively easy; we have only recommended sensible and appropriate light levels based on health, safety, performance and environmental needs. We have not changed, or more importantly, raised our illuminance recommendations in almost 20 years but we have drawn attention more and more to the quality of the light, the benefit it provides and the energy it should use. I am not expecting any change from this stance for some time. We must, however, recognise that efficient utilisation of energy is now a way of life. In the evidence to the House of Lords Select Committee on the Efficiency of Electricity Use last year I used this table (See Table 1) showing that about 15% of all electricity consumption in this country is for lighting. That is 35 million million watt hours per annum or about 4% of prime energy. Examining the break-down of usage in the various lighting sectors in the right hand column shows that just over 50% of this energy is used in commerce — not unexpected and about 20% is used in each of the industrial and domestic sectors. These consumptions however, have remained static for a number of years and should show a slight decline in the future. The savings will largely be due to the research and development effort of the industry to introduce new efficient products and improve the performance of those already established. Lamps are always the prime targets for upgrading or for replacement with equivalents. (see Table 2). All these gains have been made through

TABLE ONE

ELECTRICITY FOR LIGHTING

35,000 million kWh - 15% of total electricity consumption used for lighting

	LIGHTING		ALL ELECTRICITY	
Industry	8TWh	23%	83TWh	37%
Commerce	18TWh	51%	54TWh	24%
Public	2TWh	6%	2TWh	1%
Domestic	7TWh	20%	79TWh	35%
Others				3%
Total	**35TWh**	**100%**	**225TWh**	**100%**

NOTE

1) Public Lighting is the only separately metered lighting load
2) 33% of Commercial load is due to lighting
3) Only 10% of Industrial and Domestic load is lighting
4) Domestic lighting load - only 20% of total lighting spread over 20 million separate accounts.

TABLE TWO

ENERGY EFFICIENT LIGHTING

Lamp	Current Luminous Efficacy (lm/W) 1988	Year Lamp First Marketed	Efficacy When intro-duced (lm/W)	Efficacy Average% Increase per annum
Incandescent Lamps				
1. Carbon filament	up to 3	1880		
2. Tungsten Filament(GLS)	up to 18	1906	8	1.5
3. Tungsten Halogen	up to 30	1958	18	2.2
Gas-Discharge Lamps				
4. High Pressure Mercury	up to 60	1932	32	1.5
5. Compact Fluorescent	up to 80	1980	50	7.5
6. Double-ended fluorescent	up to 100	1938	25	6.0
7. Metal Halide	up to 100	1964	65	2.25
8. High Pressure Sodium	up to 130	1965	90	1.9
9. Low Pressure Sodium	up to 185	1932	67	3.1

Low voltage tungsten halogen spotlights with electronic transformers at Australia House London can be seen below, while right is a view of compact fluorescent wall uplights.

the advancement in lamp technology and materials. With lamps of the 1980's one can observe two notable changes. First, in size — which is synonymous with trends in electronics — that is miniaturisation and the second in performance that is large improvements in application efficiency. Let me give you a few examples:

LOW VOLTAGE HALOGEN

150W PAR 38 lamps were the obvious choice for display lighting for many years but now these are being replaced with the 50W tungsten halogen reflector lamps. The halogen lamps are one quarter of the size and use one third of the energy as the PAR 38 yet produce the same beam illuminance. The lamps work at low voltage, normally 12V, and require a transformer for direct connection into the mains. This offers an opportunity for employing electronic components in the operating circuit, and electronic transformers are already finding their way into many applications. In these the 240V mains is converted into high frequency LV supply. At high frequency the transformer size and weight are substantially reduced: typically to one tenth of those of its copper/iron counterpart. They are also cooler running, noise free and can be configured easily to fit into luminaires.

COMPACT METAL HALIDE

Another light source gaining a foothold in the display lighting area is the metal halide lamp. The large bulb type has been around for over 25 years in both clear and phosphor coated envelopes and the high efficiency and excellent colour qualities of the light are highly desirable but, because of the size and shape of the lamp, the application was limited to general purpose commercial lighting in troffers, downlights and uplights.

The recent introduction of the compact single and double ended version changed all that. These lamps are quartz jacketed to with stand the high operating temperatures and permit the bulbs to be made very small.

Today they are available in ratings up to 250W with similar performance characteristics to the glass bulb types and can be fitted into enclosed precision optics for shop and display lighting.

These lamps provide nearly three-fold improvement in efficacy with double life and therefore present a strong challenge to the tungsten halogen lamps. But, as the lamp requires a fairly bulky control gear and lengthy cool down period before restrike can commence, the immediate threat to the tungsten halogen is averted. What is now needed is the development of suitable electronic control gear.

COMPACT FLUORESCENT

Undoubtedly the greatest activity in lamps has been the miniaturisation or, more correctly, the compacting of the fluorescent lamp. A vast range of shapes, ratings and colour of these lamps has emerged. Broadly speaking there are three types in circulation. Lamps requiring external control gear usually have four pins, those which have built in starters have two pin connection and the types with built in or integral control gear have BC or ES lamp caps. These very efficient, instant start, good colour, heated cathode lamps have gained a foothold in many decorative, domestic and general lighting application areas. With long life and low power consumption the energy and maintenance cost savings are high. I have no doubt that these lamps have the potential to replace the vast numbers of GLS lamps in use today.

CONTROL GEAR

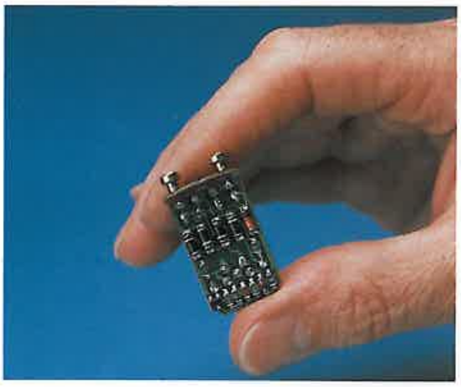
With the current lamp technology we can be fairly certain that discharge light sources will provide most of our lighting needs for sometime. But they will all need some form of control gear to start and limit the flow of current.

The rapid advance of electronics and micro chip technology indicates that the use of conventional copper and iron ballasts will decline rapidly in this decade as the problems of cost and reliability of electronic components and circuits are steadily overcome. But conventional ballasts have the merit of being simple, reliable and cheap and so will continue for sometime but with electronic ignitors and starters. These devices will simplify luminaire construction, minimise maintenance problems but will make little impact on circuit efficiency.

HF GEAR

For a long time it has been known that running fluorescent lamps on higher frequency than the mains supply improves the efficacy of the tube. Increasing the lamp's frequency about 20kHz offers a 10% improvement in efficacy.

***Below**: An electronic starter switch can without its casing.*
***Bottom**: A computer simulated colour visualisation of the lighting effects in an area with over 1,000 surfaces can be calculated in seconds.*



The exploitation of electronic circuit technology to convert mains supply to high frequency supply to lamps is now viable and economic. These mains voltage electronic ballasts with varying degrees of sophistication are already in use, but instead of generating more light output the lamp power is reduced by about 10% and maintains the light output at the 50Hz supply level.
A further benefit is that, at these high frequencies, the power dissipated in the ballast is substantially reduced. The benefits of the high frequency ballast lie not only in improved lamp efficacy and lower ballast loss, but also in reduced ballast size, weight, cool operation, silent start and running, and the absence of flicker or stroboscopic effects. The ballast is kind to lamps giving longer life and will not make repeated attempts to start defective lamps.
The compactness of the gear causes less optical interference thus resulting in higher optical efficiency of the luminaire. With some 15 — 30% lower power dissipation in the luminaire housing, this reduces the temperature in the lamp compartment and allows the lamps to run near their optimum working temperature.
Some experimental evidence shows that for sensitive people the 100Hz modulation or light pulsation can induce headaches and eye strain. But these headaches are much reduced when working under high frequency lighting — clearly this discovery can have a major effect particularly on the well being of sedentary and VDU workers.

LIGHTING MANAGEMENT

Further energy savings can be made by correctly managing the use of lighting systems. There are many methods of automatic switching available which make some 20% — 40% savings. User attitude surveys, however, show adverse reaction to switching particularly when it is linked to daylight. For minimum disturbance the daylight level should be at least twice the electric light level.
A more subtle method is offered by the controllable high frequency ballast. These ballasts for fluorescent lamps have the same efficiency, weight, size, temperature and produce the same visual comfort as the standard electronic ballast but also offer flexibility in light output control and saving of energy. The controllable ballasts have additional circuitry and include a control signal input port. The output control is achieved by varying the frequency of the inverter output. As the frequency is increased the light output and power consumption are reduced steadily.
Controllable ballasts also offer flexibility in the planning of schemes. With these it is possible to install one type of luminaire over the entire scheme and by selective control via a microprocessor the output of luminaires in various areas may be set to provide the required illuminance. When changes in the use of the area occur the lighting scheme is simply adjusted by re-programming the microprocessor. I must also add a few words of caution on radio frequency interference. 1992 is soon upon us and laws governing electromagnetic compatibility will come into force. The EMC Directive will bite into the way we exploit electronics in high frequency operation and control. The Directive not only applies to lighting but to all other building services elements such as controls and information technology systems.

OPTICAL CONTROL

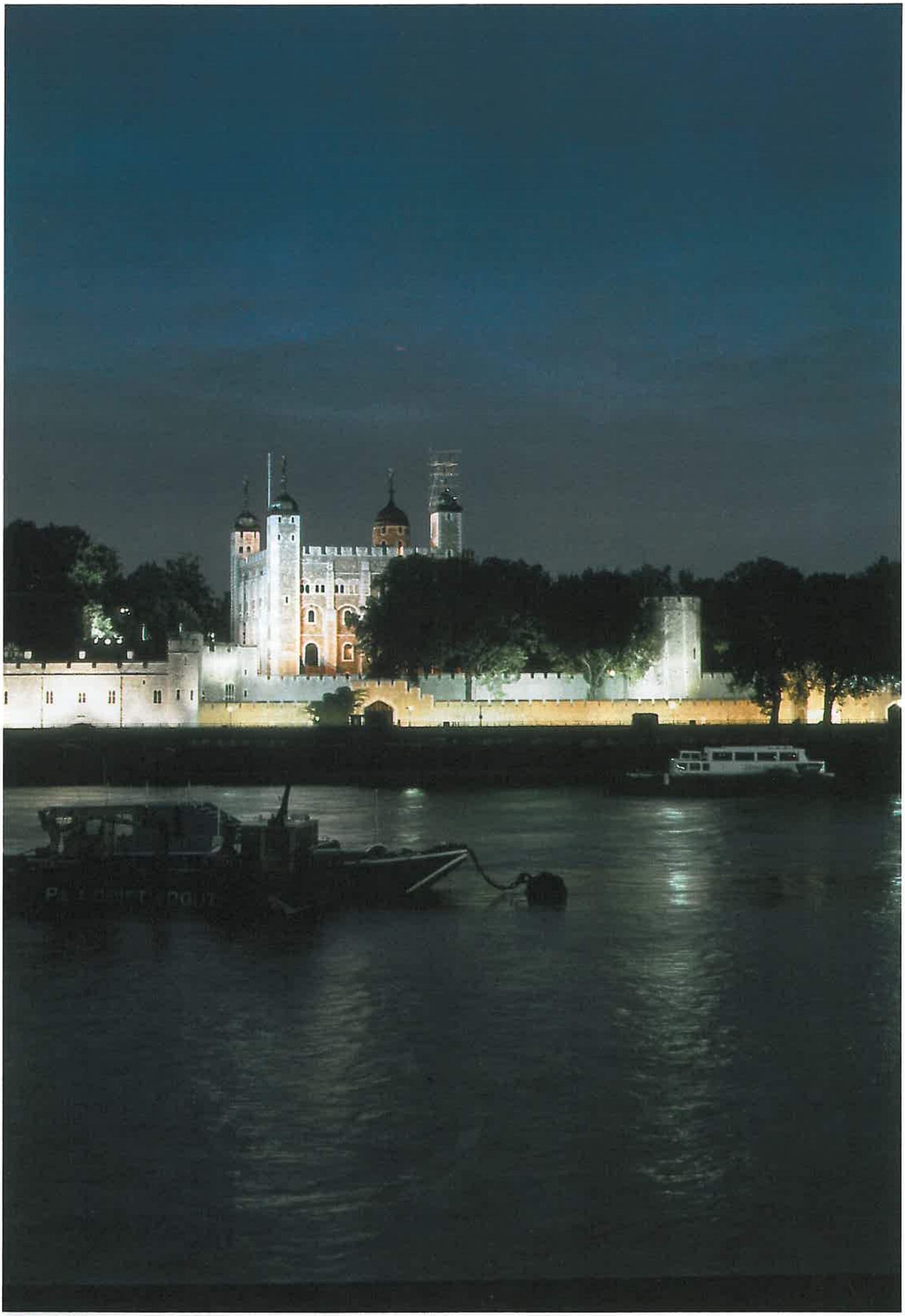
The heart of the luminaire is the optical system which determines the luminaire performance and characteristics. Here electronics, in the form of computers are used to assist in the speed and accuracy of optical designs, particularly with the sophisticated optics needed for the compact high brightness sources and luminaires that we tend to favour nowadays.
Furthermore, the computer can integrate the optical design with the mechanical design of the luminaire passing the details in computer codes to the numerically controlled manufacturing plant. CAD/CAM as it is called has become the key to quicker more flexible luminaire manufacture. But whatever the design and manufacturing process, providing effective lighting must be paramount.

LIGHTING TECHNIQUES

Lighting the changing industrial tasks such as micro-electronics assembly or automated racking warehouses is a challenge. But one of the most difficult lighting and optical design problems we have had to face is in the electronic office, where most of the visual tasks are a moving display on luminous flat, curved or inclined visual display screens. The recently launched CIBSE lighting guide for Lighting Visual Display Terminals, LG3 provides two diverse solutions for lighting such places: downlights and uplights. It is no secret that I like and promote uplights. Uplighting is ideal for all shapes and orientation of screen and is the only real solution for flat bed or drafting tables. The technique is best for exploiting the compact, high brightness lamps efficiently to generate pools of light on the ceiling. Uplights provide flexible, glare free and effective illuminance.

COMPUTER AIDED LIGHTING DESIGN

Clearly, as we grapple with the new complex and dynamic tasks we must raise our installation design process into higher technology. Today this is often taken to mean the use of computers to help with the design and optimisation of lighting solutions. More and more lighting design engineers do this and ever more ingenious lighting design aid programmes are becoming available. Computers can even be used to mimic or simulate certain installations and generate imaginative visualisations of a proposed lighting scheme.
Computers and their software are, unlikely to ever replace design flair and experience. After all, the lighting designer provides not only the human touch but he or she can apply artistic skills, use vivid imagination and make balanced compromises of intangible solutions for a lighting scheme. A designer can, from experience, make or break a set of design rules and be aware of the consequences but computers as yet cannot think for themselves they can only do what they are told to do. A program in the hands of unqualified designers is fine to carry out simple routine installation designs and should yield improvements in the produced schemes.
On the other hand, use of a very simple program by inexperienced designers can be positively harmful in the mistaken belief that the computer is infallible. Computer aided lighting design is a wonderful tool which will open many new doors but only if it is in the hands of properly educated and trained designers with access to all the latest developments. It is these such designers who will take us on to the next phase of lighting in the electronic age.



The Tower of London. The floodlighting scheme was designed to enhance the view across the River Thames. The White Tower was begun at the instigation of William the Conqueror but later work in the thirteenth and early fourteenth centuries made the Tower one of the largest concentric castles in the land.

From a distance, the old keep seems to dominate the scheme yet on closer inspection it is apparent that its military importance is comparatively insignificant. The strength of the castle lies in its inner and outer moat walls, with their flanking towers and moat and this was taken into account for the floodlighting design.

***Figure One**: Shows locations (A-D) for the siting of the 12 floodlights which are used to illuminate the famous White Tower. Key positions on the White Tower are marked A-W.*
***Figure Two** : Details the position of the floods lighting the outer moat wall, marked 1-28.*

TWO FLOODLIGHTING INSTALLATIONS

Of all exterior lighting applications, the decorative floodlighting of buildings is unique in three ways. Firstly, it is possible to use too much light: buildings which have been beaten into a luminous pulp are at the very least visually unsatisfying and frequently downright uncomfortable. Secondly, the characteristics of the surface of the building are as important as those of the illuminant. Thirdly, areas of shadow make as useful a contribution to the final effect as do illuminated areas. Here we review two unusual applications each with their own individual challenges.

FLOODLIGHTING THE TOWER OF LONDON

INTRODUCTION

Severely restricted siting locations and the great storm of 1987 posed a real challenge for the designers of the floodlighting scheme for the Tower of London. However, Brian Ayling of THORN Lighting and PSA engineers, Andy Lelliot and David Neville have achieved an effect which sensitively enhances this great building's features from all angles — particularly from the River Thames.

THE DESIGN BRIEF

The Tower of London is the capital city's most popular tourist attraction. More people visit it than any other historical monument in London and while its famous outline can be instantly recognised from any viewing angle during the day, at night time its features had a limited impact. This was mainly due to the old floodlighting scheme which was inadequate in this medium to high brightness location, so with a rise in tourism anticipated for the late 1980's, the Department of the Environment took the decision to upgrade the floodlighting scheme and improve its appearance from the River Thames.
As a result, Brian Ayling of THORN Lighting and Andy Lelliot of the PSA prepared a design based on an initial brief to floodlight the White Tower from about halfway up so that it could be viewed adequately from across the River. However, this brief was extended to include St Thomas' Tower and the outer moat wall, as time progressed.

FIGURE ONE

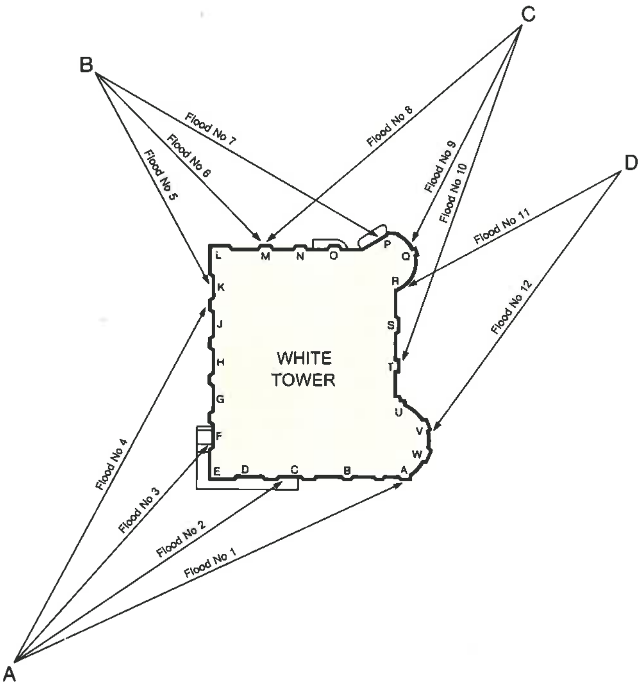
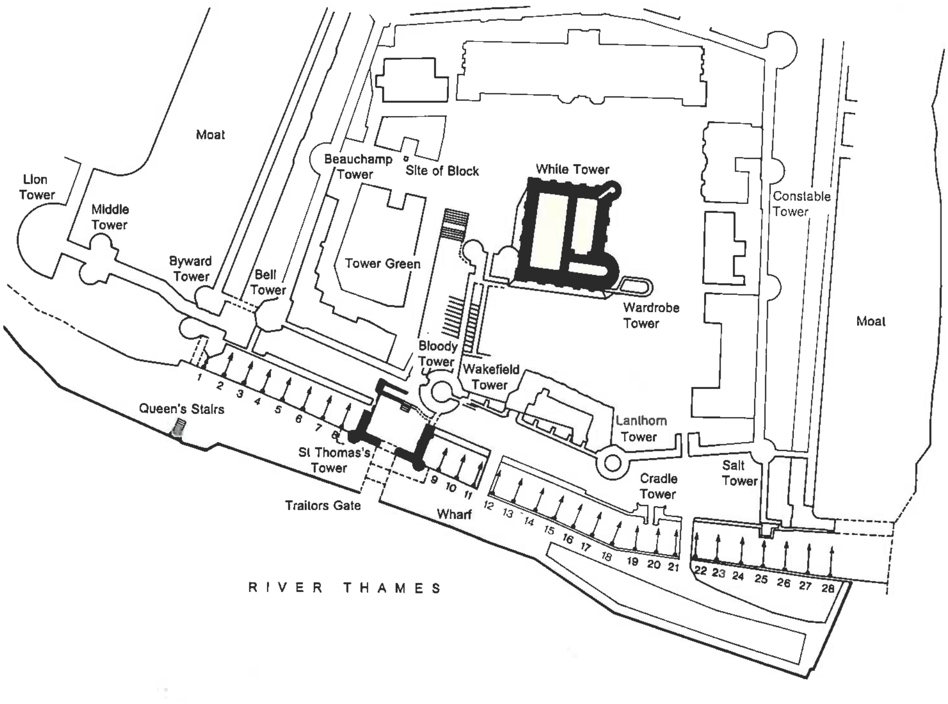


FIGURE TWO



TWO FLOODLIGHTING INSTALLATIONS

St. Thomas' Tower, part of the defences of the outer moat wall, straddles Traitor's Gate. The grid at the bottom of the page shows the horizontal illuminance values calculated for the design of this part of the scheme.

SITE SURVEY

The survey of the existing scheme revealed that illumination was being provided by fourteen 700W mercury discharge lamps in symmetrical floodlights. Not only were these inadequate in terms of output, but in some cases the floods were positioned over 70m away from the Tower, close to the River Thames. With such long throws it was hardly surprising that a high degree of atmospheric absorption (up to about 20% on nights of extreme interference) was exacerbating the problem. The recommended illuminance value average for a building with this type of stone in a medium brightness district is 90 lux and the designers used this as the goal.
Achieving this, however, proved to be quite a challenge as only four strict locations were available on which to site the floodlights and these proved to be less than suitable for the task.
The designers drew up a plan of the White Tower and marked out critical points labelled A-W. This, together with the siting locations gave initial indications of how many floods would be required but also revealed areas of weakness. It became immediately apparent that the south east corner (A and W on the plan) would be inadequately lit from the only available mounting locations (A and D) and it was noticed that an inability to aim directly at position "R" would create a lower level of illuminance on the inside radius of that particular tower. Nothing could be done about the latter, but the problem on the South East corner had to be overcome as it could be seen from the river. It was suggested that infill light was therefore provided by an additional flood, sited at ground level behind the Wardrobe Tower. Unfortunately this was not allowed and the designers had to do their best with the positions available.

THE SOLUTION

The final design proposition recommended thirteen floodlights to achieve an average 125 lux. This level was necessarily higher than the original 90 lux proposed because the application of a 0.8 maintenance factor reduced 125 lux to 100 lux and this was anticipated to be reduced by a further 10% due to atmospheric absorption on an average night.
The installed floodlights consisted of a combination of eight 250W and five 1kW metal halide lamps in projector-type fittings. Clear lamps were used in conjunction with narrow beam, long throw reflector options and the coated version was used where wider beams and shorter throws were required. The inside of the four towers facing the courtyard of the White Tower were lit with eight tungsten halogen fittings mounted in the quadrangle. Metal halide lamps were chosen as the exclusive lightsource because as with every exterior floodlighting scheme, the choice of lightsource is governed by the colour of the surface being lit.
Careful aiming was carried out based on a series of about 90 individual manual calculations because no computer aided data was available at the time of designing.
The scheme was initially carried out in 1987 and was a proven success until the Great Storm caused havoc by moving all of the carefully aimed floodlights and causing two control gearboxes to explode! The installation was realigned late in 1988 when it was decided to also light St Thomas' Tower, which straddles the world-famous Traitor's Gate.

ST THOMAS' TOWER

St Thomas' Tower is an addition to the fortifications for the Tower and had recently been extensively cleaned so that its white stonework was revealed clearly from across the river. However, from this position, the spectator can only see the top portion of the structure so the designers (David Neville had now joined the team) had to emphasise this section. In addition it was important to eliminate glare through the central gate to prevent any interference with the nightly keys ceremony which is carried out behind the walls of the Tower. The aiming of the floods therefore had to be less intense above and through the gate. (See computer plot).
The design for St Thomas' Tower consists of eight floods positioned at ground level close to the front of the main wall. Each floodlight incorporates a 150W compact metal halide lamp and a variety of different lenses available for this range of floods was used to achieve the correct distribution.
In addition, to provide more interest, the two small towers and side walls were lit with the 3000K version of the lamp while the main wall was illuminated with the new whiter 4000K version.

THE OVERALL EFFECT

The scheme is interesting because it shows how combinations of metal halide light sources can be used to create a subtle variety of effects simply from contrast and colour differences.
The overall effect gives a tiered or layered appearance with the height of the central White Tower dominating the lower levels of Traitor's Gate and the outer defensive walls. The River Thames running below and in front of the whole complex completes the picture and adds drama to one of the oldest scenes of London's history.

OUTER WALLS

Once this section of floodlighting had been installed, it was considered so successful that a speedy decision was taken to extend the scheme along the outer moat wall along the complete length of the river bank to Tower Bridge. Nearly thirty 150W metal halide floods were used for this section. The warmer 3000K version was chosen to create a contrast with the cooler colour temperature used elsewhere.
This final section of the installation "frames" the entire view of this great historic building.

St Thomas' Tower

Illuminance: On Horizontal Plane
Grid: Horizontal at z=0

	36.0	34.0	32.0	30.0	28.0	26.0	24.0	22.0	20.0	18.0	16.0	14.0	12.0	10.0	8.0	6.0	4.0	2.0
16000	39	40	40	32	29	30	31	38	57	46	36	34	32	31	36	41	38	37
14000	57	58	62	51	42	41	39	47	70	62	49	46	45	52	58	61	55	55
12000	79	78	87	75	52	50	50	53	52	65	66	60	62	72	85	82	76	76
10000	59	75	102	83	67	59	58	44	30	43	65	73	79	87	93	81	59	39
8000	40	70	92	99	83	60	46	28	17	20	37	56	58	98	91	70	39	25
6000	38	50	78	85	66	52	27	10	10	10	14	43	57	96	82	51	38	24
4000	30	43	53	20	11	8	6	4	3	2	4	7	10	21	54	43	30	17
2000	6	15	8	4	1	2	1	1	1	1	1	1	1	3	8	15	6	2

x direction ←– – –

Minimum Illumunance: 1 lux
Average Illuminance: 44 lux
Maximum Illuminance: 102 lux

Utilisation factor: 0.24
Uniformity (Min/Max): 0.01
Uniformity (Min/Avg): 0.02

***Right**: The magnificent Chateau picked out by the floodlighting.*
***Below**: Effective floodlighting of the courtyard.*
***Bottom right** may be seen the unobtrusive lighting equipment.*

A SPECTACULAR VINTAGE

INTRODUCTION

The name of Chateau D'Yquem in south west France is familiar to all students of wine, as many consider its sweet white Sauternes to be among the world's finest.
Originally built in the 12th century as a fortress, in 1785 the Chateau and its vast surrounding vineyards passed by marriage to the Lur Saluce family which is still the proprietor today. A short time ago, architect Monsieur Grech and contractor Monsieur Garcia set about planning a floodlighting scheme. The overall aim of the design being to create 'life' and produce a strong dramatic effect, while maintaining an aesthetically pleasing balance.

SOME LIGHTING PROBLEMS

The choice of light source is always the first and most important decision for a designer to make in decorative floodlighting and Chateau D'Yquem was no exception. Tungsten halogen was chosen for four main reasons: to go with the light pinkish-yellow colour of the stone; the need for small unobtrusive floodlights; a desire for instant light and the need to vary light intensity.
All too often such decisions are influenced purely by considerations of efficacy, life or cost but the designers resisted the growing trend to automatically select high pressure sodium equipment. The slight increase in energy use with tungsten halogen is not significant and the final floodlit result is most pleasing.
Choice of the correct floodlight distributions, location and aiming is the second important design decision for any scheme. Although the grounds surrounding the Chateau are extensive enough for the use of long range projectors to illuminate the main battlement walls, in practice a combination of relatively close offset floodlighting and long range units was installed. Two hundred watt rated tungsten halogen floods have been mounted at ground level just far enough back to register the wall line, with powerful narrow beam, high intensity, 300W and 500W spotlights with visors highlighting the corner turrets and other interesting shapes. The relief is then sharpened, creating a backlit effect, by some additional floodlighting from the other side of the wall. For aesthetic concerns, the floodlights have been well hidden by vegetation and, with no bulky control gear, the daytime appearance of the lighting equipment is easily kept clean and unobtrusive. By day as well as night, the installation will not damage the appearance of the site, its sole function being to bring out its quality and magic.

LIGHTING THE CHATEAU

The facade of the Chateau itself is lit in a similar manner to the walls but the dramatic effect is heightened by floor mounting the 200W floodlights closer to the building and directing them vertically at glancing angles to produce very strong shadows and marked highlights. The shadows of the roof area and turrets are then illuminated by more powerful 300W floodlights from a different direction, in this case out of eyesight, mounted at roof level. Thus the shape and form of the Chateau, especially the turrets, are emphasised. There is no dazzle or glare and the viewer's eye is not "pulled in too many directions at once".
Interestingly, the narrow beam long throw 300W and 500W floodlights have different front glass attachments, underlining the fact that not all floodlit effects need be created by reflector design alone.
The courtyard space is used as a reception area. Each year the May Musical, one of the traditional grand fetes of the Bordeaux regions, is here. Within the courtyard none of the decorative floodlights are mounted at ground level. A combination of floodlights give a low, general light and quiet ambience with key viewing positions such as arches underlined.
The final effect created is extremely impressive and the tungsten halogen floodlighting has contributed an essential element to the appearance of the building and fully justifies all the aiming and installation work.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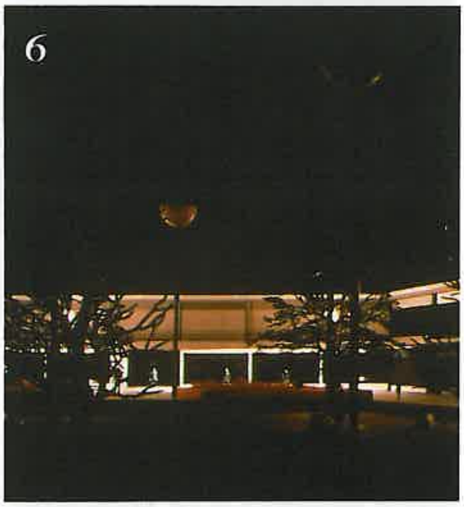
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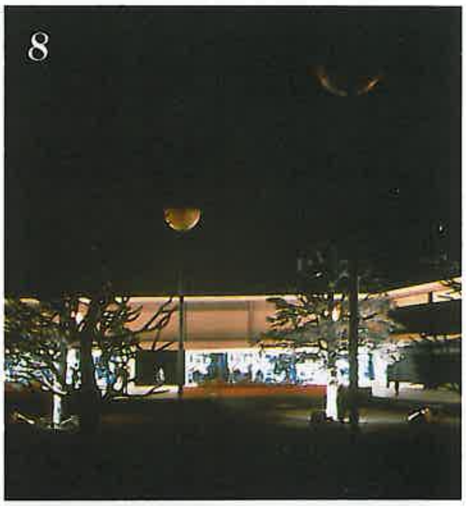
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12

The sequence of pictures shows several of the model's 13 lighting options. Table 1 on page 23 fully details the different schemes.

AMENITY LIGHTING FOR PEDESTRIAN SHOPPING AREAS THE BARTLETT PROJECT

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There is little doubt that lighting can play a major part in the visual quality of an environment, and exterior environments are no exception. In recent years, in the United Kingdom, there has been considerable development in the field of pedestrian shopping areas. The style and lay-out of these developments vary enormously, but usually they comprise a number of shop buildings grouped around a pedestrian street or square. The shop buildings are often two or more storeys high and the pedestrian area often contains trees and other architectural features. Many of these shopping areas include restaurants and public houses and also can provide areas which are used by people for evening walks.

There is considerable investment in these developments and for this reason designers wish to make them attractive and popular. Consequently they must be pleasant, safe and of a high visual quality both by day and by night. Lighting makes a major contribution to fulfilling the night-time needs and is required not only during normal shop opening hours in the winter months after sunset but also later in the evenings.

There have been a number of studies recently on the relationship between exterior lighting and crime particularly in streets and areas around housing (see Edmonton Green review LJ 31). These studies have shown, perhaps not surprisingly, that people feel more secure in areas that are well lit. Projects such as the one carried out at Edmonton Green have also shown that in areas where the amount and quality of lighting have been improved there has been a reduction in crime, particularly in muggings and crimes against the person.

This article looks at a study of exterior pedestrian shopping areas, carried out in conjunction with the Bartlett School of Architecture and Planning, University College, London. The study set out to investigate which lighting installations were preferred and to identify why they were preferred. This was done by using a combination of subjective appraisals and physical measurements, particularly in model studies.

DESIGN GUIDE THE AIM

Numerical lighting values associated with the preferred installations were considered with a view to producing a set of recommendations or a design guide to help designers of amenity lighting schemes to provide a better and more attractive night time environment, particularly for pedestrian shopping areas. The conclusions indicated that in many cases the lighting is not of a very high standard. Often there are dark areas and often the areas are lit with luminaires which have been chosen for their attractive daytime appearance rather than their lighting performance; for example, luminaires of the post-top, clear globe type are attractive by day, but at night, without any optical systems are very bright and can make seeing difficult.

THE STUDY — STAGE 1

By way of a learning exercise eight existing developments were investigated including two areas around dwellings and two enclosed courtyards. Four of the sites were situated in central London and four were in North London and Hertfordshire.

At each site two surveys were carried out. Firstly, measurements of the lighting conditions were taken and then subjective assessments of the sites by five observers using bi-polar appraisal scales were made. The questions covered both functional and aesthetic aspects.

The results from this first stage not only indicated the typical lighting conditions provided in these type of areas and the general subjective reaction to them, but also provided some very useful information about the possible requirements for lighting in these types of situation.

In particular, it appeared that it was desirable to introduce two forms of lighting: one to provide the ability to see clearly the space and the people in it — probably from a wash of light over the whole area; and the other to create visual accents by highlighting some features within the precinct. The sites benefitted from the illumination of vertical surfaces, particularly at the perimeter of the area. In addition, the need to limit the brightness of the luminaires, was identified, thus minimising discomfort glare and reducing the negative effect on the level of visual adaptation. The lighting of shop windows also proved to be of considerable benefit to the lit scene, by adding interest and providing a bright background to help reveal objects and people.

SECOND-STAGE

LABORATORY MODEL-STUDY

The first stage provided useful guidance on the possible elements which should be included in a design situation. These needed to be examined in more detail, and it was decided to test the design proposals in a model study. A detailed, 1:50 scale model was constructed to a design based loosely on a shopping precinct at Hatfield. The model comprised two parades of shops on two levels with the parades forming two sides of a square. The shop units were continuous with a canopy over. At the ground floor level in the middle of one parade a pedestrian tunnel or covered walkway was constructed. In the central square a change of pavement level

***Below**: The 1:50 laboratory scale model.*

was included as well as landscaping comprising trees and shrubs. Models of people were also included. The shop windows of one parade of shops on the ground floor were fitted with photographic transparencies of real shop windows so that when back lit they gave a good representation of shop interiors.

VARIETY OF LIGHTING SYSTEMS

The model was fitted with a variety of lighting systems typical of those normally installed at these sites. Additional lighting was included to represent the effects that were considered necessary. These included the following:

1) 10m high post-top mounted luminaires with diffusing bowl;
2) 6m high post-top mounted luminaires with clear spherical globe.
3) Under-canopy lighting incorporating covered walkway lighting.
4) Shop-window lighting.
5) Floodlighting on the trees.
6) Spot lamps mounted over the model and used to complement the post-top diffuser luminaires to create a light pattern typical of this type of luminaire.
7) Luminaires mounted over the model to provide a general wash of light.

The model lighting equipment used miniature lamps and there was good representation of full scale luminaires. All the lighting equipment was fitted with dimmers to enable the lighting levels to be adjusted.
The model was constructed to enable it to be viewed by an observer through a viewing slot positioned at the end of the model and at a normal standing height position.
In all, thirteen different lighting systems were available, as listed in the table — all based on the results of the preliminary study. These could be switched to provide a wide variety of lighting effects which were assessed by a team of seven observers again using a series of bi-polar semantic differential scales. The observers were asked to rate on a scale 1-9, questions covering issues such as uniformity, glare, and attractiveness. Care was taken to alter the order of presentation of the installations for each observer and before commencing assessments the observers were allowed time to adapt to each lighting condition.

RESULTS

The results, details in Figs. 1, 2 and 3, confirmed the findings of the first stage of the project. The installations which were preferred had a lighting system which provided an even wash of light over the area, including the vertical surfaces, and also had accent lighting. When the shop windows and the area in front of the shops were lit, this was also preferred.
The installations which were least preferred were those that had a poor illuminance uniformity and those installations that had excessively bright luminaires.

THIRD-STAGE

The final stage of the project involved a further series of site visits to recently completed shopping areas at Hanley in Staffordshire, Wolverhampton an Northampton.
These visits provided a great deal of information about current lighting practice and helped the team to verify and refine their ideas about design recommendations.

Table One *lists the lighting options, grouped into 13 different schemes.*
Figure One*: Appraisals of overall impression, lightness and attractiveness for each lighting scheme.*
Figure Two*: Appraisals of uniformity, including and excluding luminaires for each lighting scheme.*
Figure Three*: Appraisals of clarity of people and glare control for each lighting scheme.*

These figures show the appraisal values (averaged) for all the observers. In Figs 1 and 3 the scales are arranged so that the preferred or more positive attributes are higher up the page. In Fig 2 the preferred level is at the centre of the scale. The graphs show that the schemes numbered 3, 4, 12 and 13 are the best. The common characteristic of these schemes is that they all include a reasonably uniform coverage of light to which decorative or accent lighting is added. If we split the 13 schemes into three groups it can be seen from the first and third groups how, starting with a basic coverage of light, the appraisal ratings improve as the accent lighting is added. (See particularly Figs 1 and 2).

TABLE ONE

Scheme No.	Lighting options used	
1	a	1st group
2	a + d	
3	a + d + e	
4	a + d + e + f	
5	c	2nd group
6	c + d	
7	c + d + e	
8	c + d + e + f	
9	b	3rd group
10	b + d	
11	b + d + e	
12	b + d + e + f	
13	b + d + e + f + c	

a) Post-top luminaires, 10m height medium spread of light.
b) As a), but with a wide spread of light.
c) Post-top mounted luminaires, 6m height, clear spherical globe.
d) Under-canopy and covered walkway lighting.
e) Shop-window lighting.
f) Floodlighting on the trees.

FIGURE ONE

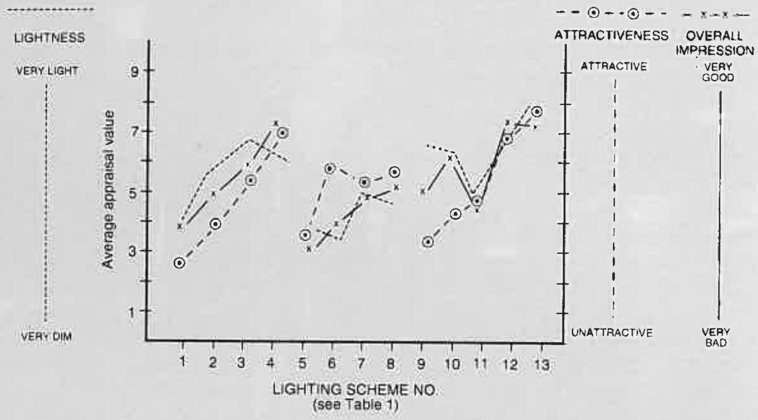


FIGURE TWO

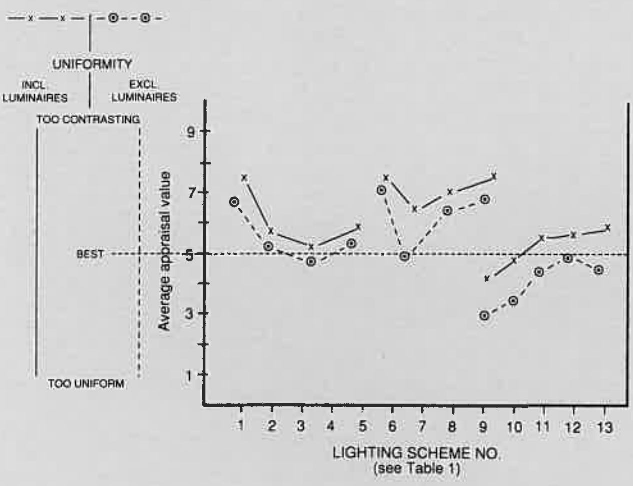
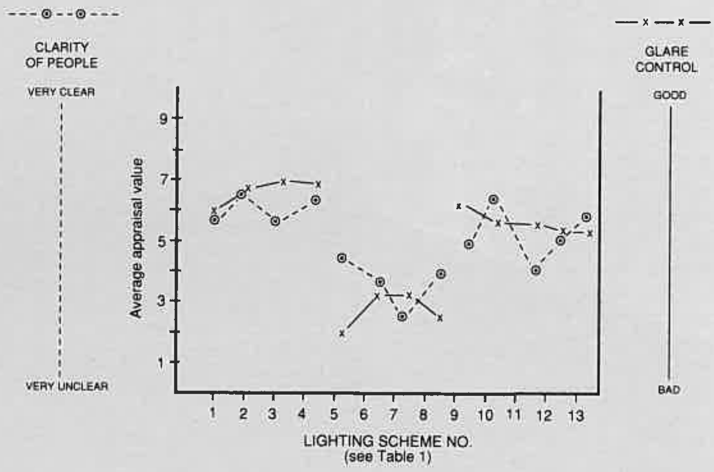


FIGURE THREE



THE DESIGN RECOMMENDATIONS

The conclusions and provisional recommendations of the study have been published in a design guide. Its proposals include recommendations for achieving an overall coverage of light with good uniformity to ensure satisfactory visibility and to create a particular atmosphere or ambience. The highlighting aspects can then be added by accenting features such as statues, trees seating areas and building facades and by using attractive luminaires to create visual interest themselves, particularly by day.
It is worth pointing out some of the key points raised. General lighting should provide a wash of light over the area with the average horizontal illuminance, 1.5m above ground level, not being less than 20 lux and uniformity not less than 0.3. Similar ratios involving vertical planes were also detailed.
In shopping precincts, the visual scene will be enhanced by having the shop windows lit, particularly after closing time. Lighting under shop canopies is also important to avoid people being seen in silhouette form. Covered walkways should have continuous lighting throughout their length which also lights vertical surfaces.
The study also stressed the importance of limiting the luminance of luminaires in normal directions of view and the need for lanterns and columns to form an integrated part of the design by day as well as night.
These guidelines form the basis for creating a better, more attractive night time environment and are not rigid rules. Lighting for pedestrian areas must provide good seeing conditions over the entire area and a light pattern that is attractive and welcoming.

NEW INSTALLATIONS

The lighting schemes illustrated on this page show something both of the versatility of the types of light fittings and the international use of this equipment.

STOREBRAND IN NORWAY

Storebrand is Norway's leading insurance company. Its new head office in Bergen makes dramatic use of amenity lanterns. Shown are a number of 125W mercury lanterns which enhance the copper columns.
The interior has received the low energy compact fluorescent treatment. A most imaginitive free standing uplight scheme has been installed. Each 1900mm high fitting uses four 38W 2D compact lamps three for uplighting and one for downlighting.

A FRENCH SHOPPING CENTRE

Many of today's large retail concerns favour the 'crisp' and 'even' lighting approach. Light it well with good uniformity and colour rendering so that customers can examine merchandise easily anywhere in the store. With careful attention to aesthetics the luminaires will work discreetly, without distracting the customers yet still tempting people into the store to buy. The giant 8,100m^2 Leclerc hypermarket in Maurepas, Paris is no exception. Over 600 low bay 400W metal halide luminaires with aluminium louvres have been installed. Within the first year of operation over 12,000 customers visited the store each Saturday.

A WELSH CHURCH

Nestling within the heart of Swansea, surrounded by shopping complexes and roadways, lies St Mary's Church. While the building and grounds provided a visual feature and tourist attraction for the city by day the site created an unlit 'hole' during the darkness hours.
Late night vandalism and the wasting of an aesthetic opportunity prompted Swansea City Council towards a lighting scheme for the church. The South Western Electricity Board took on the project.
Because of the nature and layout of the area immediately surrounding the church, each side of the structure had to be considered virtually as a single entity. High pressure sodium lamps (SON) were chosen for almost all the lighting positions as it was felt that this lamp type best complemented the natural colour of the building stone.

The western side is illuminated by two 250W SON floodlights washing the facade at a broad angle. A single 150W luminaire supplements the lighting level at the south west corner. The northern side is lit by two different lamp ratings. The lower section is illuminated by 150W SON, while, because of space restrictions that prevent floodlights being set far back from the church, upper levels are lit by seven roof mounted 70W units. The illumination from these and the positions chosen were designed to enhance the architecture without breaking up the natural lines of the building.
The eastern side faces on to a main road and this section was left unlit so that floodlighting does not distract passing motorists, although a single metal halide source, fixed in position, picks out a cross mounted on the top of the church roof. On the southern side, the projector positions were chosen close to the building to prevent shadowing and obstruction by nearby trees. Again, roof mounted floodlights illuminate the upper levels.
The main tower, on the southern side, is lit on three sides by ground mounted 250W narrow vertical beam floodlights from close offset, which send shafts of light up the tower walls. The north face is lit by a roof mounted 150W floodlight.
The top of the tower is picked out by a 150W metal halide lamp, with a stipple effect glass cover. A second metal halide lamp, with a plain glass cover, highlights the clock-face and green slats behind the clock. All the lighting is activated by a photocell with a manual override. Feedback from Swansea's residents suggests that local population is happy with the night-time appearance and the well-illuminated area now suffers from virtually no vandalism.

A TENNIS CLUB IN AUSTRIA

An interesting installation has recently been completed at the LaVille tennis club in Vienna, Austria. In total there are six tennis courts used for leisure sports and club competitions. The scheme put forward comprised 38 twin fluorescent fittings per court mounted on special trunking giving an average illuminance of 400 lux. Each fitting is high frequency and the total installation is controlled by a lighting management system which incorporates daylight.

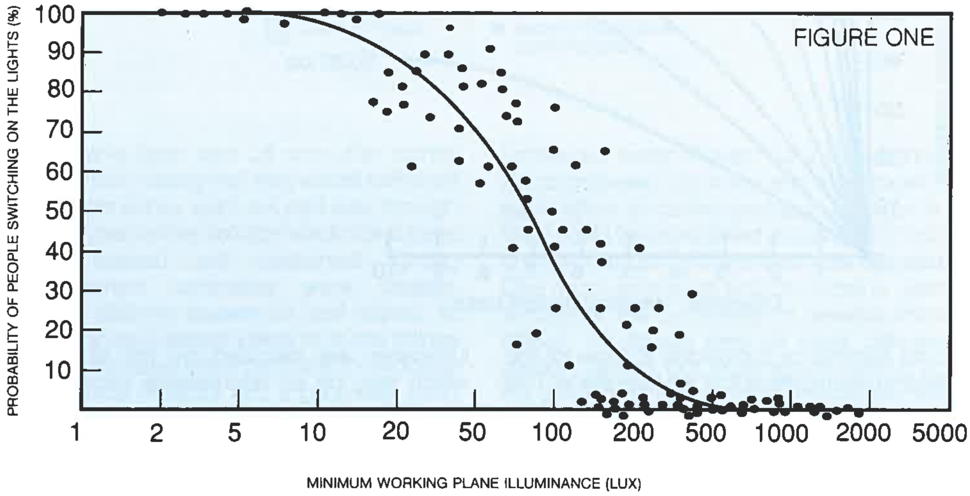

FIRE

***Left**: An energy efficient environment has been created at L'Oreal Golden.*
***Figure One**: Probability of switching on lights.*
***Below**: A straightforward local four button switch plate.*

A MATTER OF CONTROL

Lighting is often thought of as if it is something a building needs. But it isn't. Lighting is there to be an asset which helps the occupants do their job. Without lighting they cannot see, but without them, there is no need for the lighting to be on. The aim of good lighting control is to ensure that all occupants have exactly the lighting they want when they need it, ie, to ensure that all unwanted use is eliminated.

Most lighting control systems fall into one of the following categories: switch control, dimming, controllable ballasts, mainsborne signalling and self contained 'intelligent' luminaires. This article examines each type and then reviews with practical examples typical usage. Frequently a combination of systems is used, dependent on the particular application.



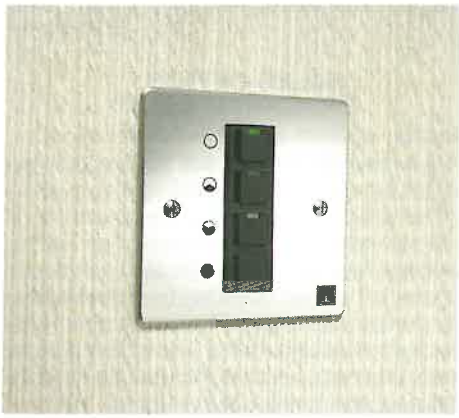
SWITCH CONTROL

If the building receives adequate daylight for part of the day then artificial lighting is not required and could be switched off or dimmed. The simplest and most common method of control is to encourage people to switch off unwanted lighting. This is not usually very effective but self-adhesive labels, reminding people to turn off unwanted lighting, are always a worthwhile investment.

DAYLIGHTING AND SWITCHING

Fig 1 shows (for the UK) how the probability that lights will be switched on varies with time of day and the degree of daylighting.

If the occupants of a typical office commence work at 8 o'clock then, on average throughout the year they will tend to turn on 50% to 60% of the lights, and they will normally stay on through the day, probably until the cleaners depart.



If, however, we could trigger the lights off when the occupants are at lunch, then only about 20% would be switched back on because they will feel that there is enough daylight. Lighting will gradually be turned on as the daylight fades, but there will be a major saving in energy.

Of course we could keep on turning the lights off through the day, but this would be very annoying, save little extra and probably make people develop a "switch on habit", so a lunchtime switch-off would be best.

We can also trigger the lights off after business hours. Anyone still working can switch them on. Infra-red, ultra sonic and other forms of remote switch can help to provide more flexibility in switching and are becoming popular. These allow individuals or small groups to control lighting in their part of the office and help to stop switching more than they need.

Combined daylight and artificial lighting systems can be designed in which the available daylight is "topped up" by the electric lighting. These can be automatic or manual, with the rows of fittings near the windows being switched off or preferably dimmed, as bulk switching annoys many office workers, when there is sufficient daylight.

THE CONTROLLABLE BALLAST

A system which dims up and down is better than one which switches on and off. There are two reasons. Firstly the savings are much greater and secondly dimming is less obtrusive. We could use conventional dimmers to achieve this but a better method is offered by controllable high frequency ballasts which adjust the light output from fluorescent fittings in response to management commands. Typically such ballasts are directly controlled by instructions from intelligent controllers which would use inputs from time switches, clocks, photocells or presence detectors. However an important element not to be overlooked is the local switch or "dimmer" control which gives the occupant the ability to override any setting.

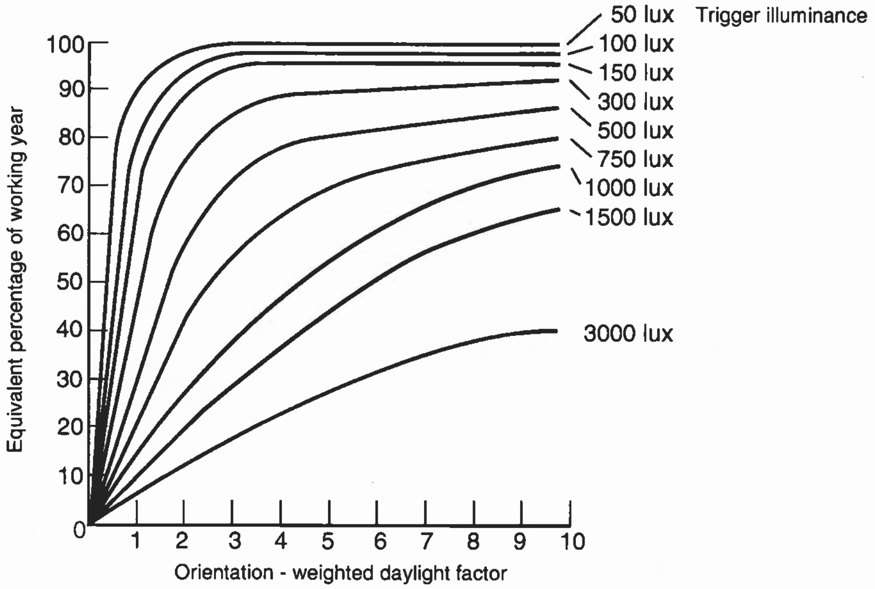
The most obvious application of the controllable ballast is to reduce the light output of the luminaires when daylight is available. Instructions to the ballasts within the luminaires are based on information from a photocell that monitors the light level on the task.

As more daylight arrives on the work plane from the windows so the output from the luminaire is smoothly reduced. This control avoids any sudden changes in illuminance and can save more energy but, of course, it is more expensive than the switching arrangement. We can see from figure 2 that if the daylight factor at the desk is 5% and we want to provide 500 lux, then a controllable ballast dimming system linked to daylight levels could save 70% of the lighting energy during the working day. It is these potential savings that explains the renewed interest in daylight design and daylight penetration into buildings.

The photocell control will also monitor and maintain a large installation at a constant illuminance. In a conventional installation

***Figure Two**: Percentage of a normal working year during which luminaires would have to be switched off in order to ensure the same energy saving as dimming (top-up control).*

FIGURE TWO



more illuminance is provided to allow for the dirt and depreciation that will take place. This waste is avoidable. Initially the lamps will be dimmed down to give the design light output. But as the light losses (caused by aged and dirty lamps and reflectors) mount over a period the power to the lamps will be gradually increased automatically and raise the light output to cover the losses and maintain constant illuminance. Maximum power will only be called for when maintenance of the scheme is due, rather than all the time.
With controllable ballasts it is possible to install one type of luminaire throughout but the output of luminaires in various areas may be set to provide the required illuminance. When changes in the use of the area occur, and these days offices are reconfigured regularly, the illuminance level is simply adjusted by re programming to match the new use for the space.
Dedicated time controllers can be used to programme the lighting to switch on or off and change illumination levels to match the different activities that occur during a normal day. These range from normal office work, to cleaning and security. For instance an office worker switching on a light in the day might get 500 lux, but the same switch could give a security guard 250 lux for his patrol.
Such systems give great flexibility and control to the occupants which increases their efficiency and effectiveness. In addition there are sound physiological and psychological reasons why people work much better when they like their environment and can control it. People must always be able to override the system if they wish, otherwise they will not work well and will deliberately try to defeat the system.

BUILDING MANAGEMENT

Lighting controls can be linked into a central control system to control the lighting of a complete building and the other services in the building or site. This considerably extends the scope of energy management with facilities for load shedding or phased switching to avoid excessive maximum demand charges. The control signals for the system maybe distributed by twisted pairs of wires, coaxial cables or be injected into the mains cabling system. The signals in the luminaires are decoded by the receiver which may be an addressable micro-chip driving the electronic ballasts.
Any system of control needs a channel to carry the signals. In a conventional system this is the switch "drop" which carries the live conductor from the mains to the switch and then to the luminaire. More sophisticated signalling systems use extra low voltage cable, coaxial cables and so on. There are two problems. First these control circuits have to be installed in the first place and usually the installation work is more expensive than the cables. But since they are a substitute for conventional wiring of switches, this is not normally a problem. But the second snag is that any change to the layout calls for the cables to be re-wired. The low voltage control systems of some lighting management products are easier to reconfigure than conventional wiring, but they do have to be reconfigured.
The perfect solution would be to use some existing communication channel. We could, for example signal through the air by infra red radio or ultrasonics, but these can be unreliable and have other problems. There is however, one channel which is already wired into each luminaire without fail — the mains and we can use this.

MAINSBORNE SIGNALLING

Mainsborne signalling systems are becoming more popular and use the mains wiring to the building in order to transmit high frequency coded signals from selectively located transmitter units to the luminaires. It is simple and inexpensive to install or retrofit because no expensive signal wires are required. The receivers are located either in individual luminaires or in separate boxes to control a group of luminaires. Each receiver can respond to many codes, allowing luminaires to be "addressed" independently or in groups. Changing this "address" is easily done, by a series of coded switches on each receiver, allowing amendments to the switching pattern without alteration to the wiring. These systems offer tremendous flexibility of operation and their use will continue to grow.
A final approach, is the self contained 'intelligent' light fitting. These modular luminaires contain a pre-set photo electric cell and passive infra red detector. The light output is adjusted according to the amount of daylight available but is only provided if someone is actually working underneath in a zone around the luminaire. The fitting will detect an absence of 10-15 minutes and switch itself off, switching on again immediately it detects the presence of an approaching person. Additionally because it is totally self contained and is connected directly to the lighting ring circuit it has no need for further wall switches or links to remote control systems. Installed at the correct spacing the fittings need not be repositioned or added to if the office area is reconfigured, thus saving on cost, time and disruption.
Having reviewed the various lighting control systems available how are they used in practice?

CASE STUDY 1 — THORN DIDSBURY

The new THORN Lighting North West Regional Sales Office was designed to illustrate the latest lighting control techniques — mainsborne signalling, controllable HF ballasts with various automatic sensors and self contained 'intelligent' luminaires.
The reasons why each system is used in particular areas will become clear as each workspace is examined in turn.
Situated at Didsbury about 4 miles south of Manchester city centre the 10,000 sq. ft. green glass 'Pavilion style' office houses 28 people; management, lighting engineers and office staff.

RECEPTION

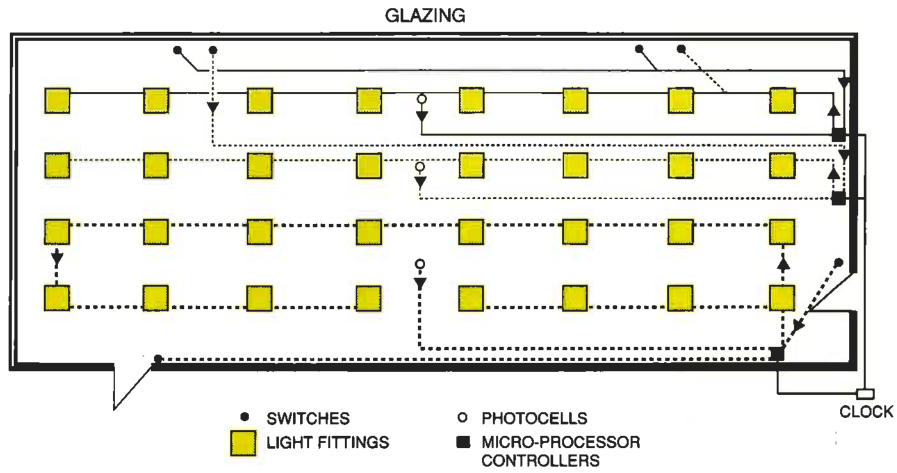
This area has exposed trusses which naturally led to an uplighting solution. Four quarter sphere metal halide uplights were installed. Highlighting is achieved by corner mounted metal halide spotlights fitted with louvres. Two of the uplights are left on permanently for security and aesthetic reasons. The remainder, together with the spotlights are switched off by mains signalling at the end of each working day.

SALES-OFFICE

Modular 600mm square recessed fluorescent luminaires with 16 cell VDT reflectors complying with the CIBSE VDT lighting guide, are used to provide the accurate optical control required in this computerised office. Each luminaire has two 40 Watt bi axial compact fluorescent lamps, operated by controllable high frequency ballasts. The luminaires interface with various sensors. The scheme has been designed to allow a maximum average illuminance of up to 700 lux at desk height,

***Figure Three**: Luminaires controlled by 3 photocells and micro processor controllers via low voltage wiring.*
***Figure Four**: Plan of lighting control for the secretarial offices.*

FIGURE THREE



although 500 lux is more appropriate for an office such as this.
One of the benefits of this system is the facility to pre-set the illuminance below 100%. On this occasion a pre-set allowing only about 70% power consumption produces a corresponding illuminance of around the 500 lux needed. This may seem like over lighting but the initial illuminance on any scheme must allow for dirt and depreciation. In this case we are saving that wasted energy. The extra theoretical capacity of the installation will only be used as the installation gets dirty and the lamps age.
Because two of the office walls are glass it was logical to install photocell control to maintain illuminance by dimming the lighting as the daylight contribution increases. This is achieved by using three zones (see figure 3) each with an 'Internal' photocell measuring working plane illuminances. Light output varies smoothly between 25% and the 70% pre-set value, with resultant savings in energy consumption. In fact experience to date (November 90 - May 91) shows that most luminaires are off or operate at lower output until late afternoon when natural light begins to fade and light output from the luminaires is automatically increased.
Local micro-processor controllers address groups of luminaires in response to control inputs from either Photocells, a programmable time controller or any of the several four button switch plates within the office. The local four button switch plate allows the occupants to select their preferred level of illumination, though the photocell will not allow any selection that would exceed 500 lux.
This stand alone system is controlled by a Programmable Time Controller (PTC). Unlike the timer within a conventional building management system, the PTC can reduce and increase light levels any number of times per day. The PTC is programmed to 'send down' signals at 5.30pm, repeated at 30 minute intervals. A 'down' signal changes the lighting status from its current level to the next lower setting, ie preset to 40%, 40% to 25%, 25% to off. In practice, the first 'down' signal at 5.30 will normally reduce the lighting level to 40%, but if people are working late they simply restore maximum via the local wall switch. If there is no response subsequent 'down' signals will eventually turn all the lights off.

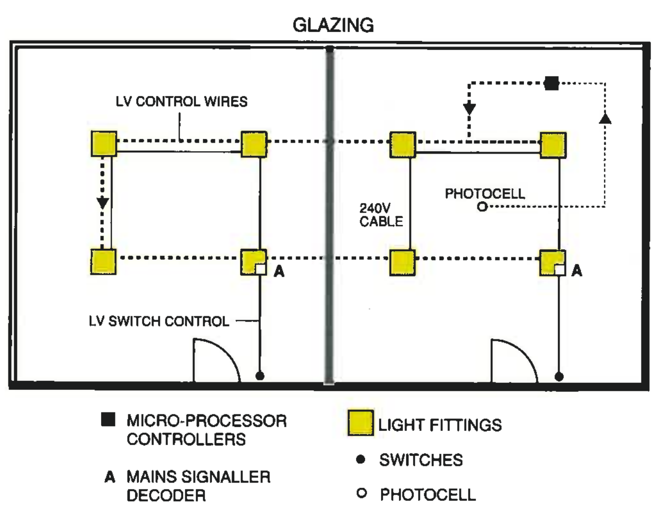
SALES MANAGERS

Sales managers are often out leaving their offices unattended during normal working hours. They can also be in long after most office staff have left for home. Either mainsborne signalling or a controllable ballast system could have been introduced with regular off signals programmed throughout the day, accepting the inevitable complaints when lights extinguished whilst the office was occupied. Alternatively signals could have been sent off only after normal office hours, hoping that they would switch off their lights if they went out part way through the day, but neither solution would have been ideal. Instead self contained lighting management luminaires were chosen. With a 600mm square 16 cell louvre, its appearance is almost identical to the fittings used in the sales office but these incorporate a presence detector and a photocell. Each luminaire operates independently without any external switch and simply detects presence, or lack of it.
The controllable high frequency ballast is regulated by a photocell which measures working plane illuminance and if an office is empty for more than about ten to fifteen minutes the luminaires switch off. Foolproof. Though we doubt that the sales managers will appreciate the description, they prefer to call them intelligent luminaires!

SECRETARIAL AREA

These offices have large areas of window, so photocell controlled high frequency luminaires were chosen. To install a local micro processor controller and a photocell in each office to control perhaps only four fittings could be considered extravagant, if not uneconomic, so a compromise was reached. One micro-processor and photocell is used to control the luminaires in several small offices. Of course they all have different daylight factors but locating and setting up the cell in the darkest offices means that the others must have adequate illumination. (See fig 4).
Ordinarily the micro processor would switch all luminaires on the circuit, which would have meant that separate offices could only be controlled from a central point. At times this could be inconvenient and wasteful, so in these offices the micro processor is used only to interpret the photocell requirements, not for switching. Introducing a mains signalling decoder into each office, linked to a local momentary action wall switch restores, individual control. Lights respond conventionally to the switch on the wall and staff are unaware of the light output variation — it just shows up in the lower electricity bills.

FIGURE FOUR



Below *is a general view of the Didsbury lighting engineering department and to the right the main entrance area.*

LIGHTING ENGINEERING DEPARTMENT

Architectural design and internal office layouts have resulted in this office having less natural light than those previously described. In consequence photocell control has not been used in this area. To retain appearance the theme of using 600mm square, 16 cell louvres, with compact fluorescent lamps and electronic high frequency control gear has been followed. For switching purposes there are two circuits with alternative luminaires providing a 50% illumination level. Each circuit is connected to a mains signalling receiver, mounted in a luminaire, and programmed to respond at different times. In this way the office is not plunged into darkness with each off signal, just to half lighting. Anyone working late simply restores full illumination via the wall switches.

For demonstration purposes the office is also equipped with free standing metal halide uplights so that the quality of light produced by two schemes can be compared. In practice the engineers prefer the uplighting solution. A mains signalling receiver had been fitted in each uplight. One of the benefits of using mains signalling is that the uplights can be plugged into any of the floor socket outlets and still be controlled by the building management system. Control is arranged so that only half are switched with each off signal.

Each uplight has its own switch for local override and for convenience the standard wall mounted light switch has been replaced by a mains signalling injector.

COFFEE SHOP

The area is intended for relaxation and has three independent lighting solutions to create different atmospheres. The mains-borne system is programmed to switch off all lights after coffee breaks and lunch hours.

SHOWROOM

Variable lighting for different functions is provided. House lighting within the showroom comprises of concealed variable output fluorescent fittings, and low voltage tungsten halogen downlights. The tungsten halogen and fluorescent luminaires are each connected to a dimmer, and the dimmers are linked by a common wall switch. In fact the switch is a four button plate, and each button introduces a pre-set scene.

COMMISSIONING

With two Energy Management systems and relatively new technology it was initially thought that commissioning the installation and setting up of the various components such as micro processors and photocells would be difficult. In practice commissioning was achieved in a couple of hours.

CASE STUDY 2 — L'OREAL GOLDEN LLANTRISANT

L'Oreal Golden manufactures and sells a wide range of very successful beauty and healthcare products. The operation at Llantrisant in South Wales has recently been extended to provide extra packaging capacity and much consideration has been given to a high quality appearance which optimises staff comfort. For instance a pastel colour scheme has been applied to architectural details, the machinery and even the special sound reducing slatted roof.

The company is environmentally conscious — having been one of the first manufacturers to eliminate CFCs from its aerosols. While a lighting design had been provided initially for a conventional fluorescent reflector system, it was not surprising that an energy management system was specified.

The main feature of this lighting system is the adaptation to an industrial area of energy management lighting equipment, of both variable control and switched type, normally used in a commercial environment.

As the building features large rooflights which provide substantial daylight within the main factory area, it was logical to provide a design that would best operate the lighting in conjunction with the daylight. A system using controllable electronic HF ballasts in conjunction with photocells, micro processors and programmable clocks was eventually chosen because it combines all the elements of sound energy management principles with optimum user-control. It is also flexible enough to cope with the three different factory areas identified by L'Oreal Golden.

The brief called for 400 lux on the working plane, but the scheme was designed to 500 lux nominal to allow for obstruction losses that were bound to occur after installation of the packaging machinery. Measured illuminance has subsequently confirmed this assessment.

Multi-phosphor 3500K tubes were utilised to obtain maximum efficiency in terms of light output and lumen maintenance. Colour rendering was also important to maintain the high quality appearance in the factory, and good colour-judgement is for the operator. It is a maxim in all good factories that they need good lighting, not to spot when things go wrong, but to constantly see that everything is going right.

The luminaires selected were simple battens with metal reflector attachments, and the proposed layout planned rows of luminaires to run between the vertical ceiling slats. Twin 1500mm 58 watt units were used throughout to provide a common size of fitting irrespective of method of control.

The total floor space, some 1800m², was split into three areas each controlled and lit in a different way. The main area lighting between rooflights is lit with controllable high frequency fittings operated by a controller. This controls the lighting information from photocells set within the slatted ceiling. They monitor the workplace illuminance levels and the light output is varied between 25% - 100% to "top-up" the daylight variation. The system is designed so that the fittings do not turn completely off under high daylight levels. The luminaires are equipped with relays so that they can be turned off manually from a push button override control.

The luminaires located within the rooflight areas (8 per rooflight) are obviously above the strongest daylight illuminated areas. Here, standard luminaires with High Frequency ballasts are switched by photocell switch devices operating via a contactor. These will sense approximately 1500 lux locally before switching off. The access thoroughfare, down one side of the factory is lit by a further row of high frequency ballasted reflector luminaires with standard manual switching. These lights are on at all working times.

The installation has been fully commissioned with specially designed photocells to cope with the 5m mounting height. On commissioning, the system was working, well, varying lamp output with daylight whilst maintaining task illuminanance levels.

L'Oreal factory management can simply adjust the system to become more or less sensitive to daylight from a simple special wall mounted trimming device. The system is achieving good energy savings and should the use of the area be changed then the flexible lighting will allow for the necessary re-programming. Eventually the new lighting installation will be coupled to the existing energy management system presently in use and controlling the overall factory installation.

CASE STUDY 3 — THORN BOREHAMWOOD

At this new, three storey, glass clad head-office particular attention was paid to four criteria — energy efficient light sources, high frequency control gear, optimised luminaire optics and lighting controls.

The overriding feature of the lighting design brief was flexibility and the architect had through a spacious central atrium provided

At the foot of the page is a typical office area with large windows.

penetration of daylight into the building. Throughout the general office areas 600mm square fully recessed modular fluorescents were selected with low brightness 16 cell louvre attachments. The luminaires incorporate HF electronic control gear which is dimmable and are addressed from the lighting control system. This HF gear operates 2 x 2L 40W 3500K linear compact fluorescent lamps.

The luminaires are generally arranged on a regular 2.4 x 2.4m spacing to provide an horizontal illuminance of 500 lux at desk top level although in a number of areas this spacing has been adjusted to suit office layouts. Circuit efficiency for the fittings is 81 lumens per watt with an uncontrolled loading of 15 W/m². In certain locations wall mounted compact fluorescent uplights with compact fluorescent lamps provide areas of visual interest through increased wall and ceiling brightness helping to "soften" the lighting effect that VDT compliance causes.

LIGHTING CONTROL

The high levels of daylight penetration into the building provide more than sufficient illuminance at desk level to comply with the lighting requirements of 500 lux for normal office environments. During commissioning initial lamp power was set between 40 and 60% to achieve 500 lux, reducing energy consumption to 6.5W/m² excluding daylight and time control. Therefore by dimming down or switching off the surplus artificial lighting substantial savings in electrical consumption can be made.

Like L'Oreal Golden a lighting management system was installed specifically to provide lighting control tailored to the area/task requirements.

Luminaires with electronic HF ballasts are controlled by areas (or different departments). On each floor groups of luminaires are controlled by a local micro processor which is programmed to provide different levels of pre-set illuminance.

This unit addresses its own group of luminaires in response to control inputs from either: local photocells (internally mounted), local wall mounted 4 button switch plate or the central Building Management System. Luminaires are dimmed up or down between 25% - 100% to maintain the design illuminance level at desk level or are switched off according to the building occupancy requirements by the central controller. The central controller is programmed to switch the local micro processors or collectively or by floor at times to suit the occupancy pattern of the building.

Local wall mounted controls (the four button switch plate) allow a manual override for dimming down only or switching off of luminaires. The switch plate is the usual way of switching on office lighting at the start of normal office hours as the central controller is not programmed to switch the office lighting on.

The majority of the luminaires are controlled by the photocell, local wall plate and central controller, however there are a number of areas where small groups of luminaires are without photocell control as daylight penetration is poor. In all instances photocell commands override local wall mounted controls.

CORRIDOR LIGHTING

A separate lighting system is used for the corridors using fully recessed circular low energy 13W compact fluorescent downlights with gold reflectors. Emergency lighting versions are included. In a number of corridor areas the downlight is used in conjunction with 21W wall mounted compact fluorescent uplight to provide areas of increased wall and ceiling brightness to "soften" the downlight effect. All corridor luminaires are controlled by mains borne signalling techniques where lighting control commands are super imposed in the electrical feeds to receivers that switch lighting circuits on or off at predetermined times.

At Borehamwood 50% of the luminaires are turned on at 7.30am with the remainder 50% switched on by the central controller at 8.30am or manually at locally positioned switches.

If the lighting is left on outside normal office hours in a manually operated mode the central controller will turn off the lighting after a pre determined period (30 minutes).

2ND FLOOR — DIRECTORS SUITES AND DIRECTORS SECRETARIAL OFFICES

A similar lighting treatment has been applied to the 2nd floor but with the addition of recessed and eyeball low voltage brass coloured downlights and a few 250W de luxe high pressure sodium uplights.

In each of the director suites control of the lighting is provided from a cast brass, touch sensitive control plate adjacent to the door, which also incorporates programming facilities for the lighting dimming circuit.

Four lighting switch control circuits are provided to enable various lighting moods to be selected to suit the requirements of the occupant.

The touch sensitive controls for the Secretarial Offices are similar in design and finish to those in the Directors Suites but with four button manual control for the local micro processor to control high frequence dimmable fluorescent luminaires and an ON/OFF facility for the fluorescent wall lights.

DINING AND CONFERENCE ROOMS

A more decorative approach is used for these areas by the use of fully recessed and eyeball low voltage spotlights and wall mounted 28W compact fluorescent semi indirect luminaires.

Once again a choice of switching is provided, for example the Conference Room has four control circuits: perimeter downlights; table downlights; wall mounted luminaires and picture spotlights.

The lst and 2nd circuits have switch/dimming capabilities while the 3rd and 4th circuits ON/OFF control only.

ATRIUM

The atrium represents the focal point of interest for the building with the excellent plantings at ground floor level adding a vivid colour. Unfortunately once the daylight dims so the effect of the atrium diminishes and its attraction is lost. Furthermore, as with most atria, the period through the year when sunlight can actually shine in is very limited. A lighting system using 150W metal halide spotlights (3000°K and 4000°K) therefore operates, simulating the effect of sunlight into the atrium. By altering which units are on, the effect of sunlight tracking can be simulated. These spotlights are controlled from a dedicated central controller where each spotlight is prompted to switch on at a predetermined time in relation to adjacent spotlights thus simulating the movement of the sun through its trajectory in the sky.

The spotlights are electrically connected to a switching unit which accepts signals from the central controller - a photocell monitors atrium illuminance levels and on sunny days the lighting switches off.

After sunset the spotlights are programmed for a general lighting effect to ensure the atrium remains a central focal point.

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